

QUALITY ASSURANCE PROJECT PLAN

For

**Dimock Residential Groundwater Site
Dimock, Susquehanna County, Pennsylvania
TDD No: TL01-11-12-001
Contract No: EP-S3-10-04**



**EPA Region III
START IV - West
Superfund Technical Assessment and Response Team**

Submitted to: Richard Fetzer, On-Scene Coordinator
United States Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, Pennsylvania 19103

February 2012

QUALITY ASSURANCE PROJECT PLAN

Dimock Residential Groundwater Site
Dimock, Susquehanna County, Pennsylvania
EPA Region 3

February 2012

Prepared by:

TechLaw, Inc.

Approved:




TechLaw START Region 3 Point of Contact

2/5/2012

Date

Approved:



TechLaw Quality Assurance Officer

2/5/2012

Date

Approved:



TechLaw Site Lead

2/5/2012

Date

Approved:

EPA Region 3 Quality Assurance Officer

Date

Approved:

EPA Region 3 Task Order Manager

Date

Record of Changes

[illegible]

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Distribution List

██████████ – TechLaw Site Lead
██████████ TechLaw Point of Contact
██████████ - TechLaw QA Officer
Mr. R. Fetzer - EPA Region 3 Work Assignment Manager
Mr. R. Rupert – EPA Region 3 On-Scene Coordinator
EPA Region 3 QA Officer

ACRONYMS

| | |
|--------|--|
| CLP | Contract Laboratory Program |
| DO | Dissolved Oxygen |
| DQO | Data Quality Objective |
| EDD | Electronic Data Deliverable |
| EPA | Environmental Protection Agency |
| ERT | Environmental Response Team |
| ESAT | Environmental Services Assessment Team |
| GPS | Global Positioning System |
| GRO | Gasoline Range Organics |
| HASP | Health and Safety Plan |
| ICS | Incident Command System |
| LAT | Laboratory Assistance Team |
| LCS | Laboratory Control Sample |
| MDL | Method Detection Limit |
| MS/MSD | Matrix Spike/Matrix Spike Duplicate |
| OASQA | Office of Analytical Services and Quality Assurance |
| ORP | Oxidation Reduction Potential |
| OSC | On-Scene Coordinator |
| PA | Pennsylvania |
| PAGWIS | Pennsylvania Ground Water Information System |
| PARCC | Precision, Accuracy, Representativeness, Comparability, and Completeness |
| POC | Point of Contact |
| PQAPP | Program Quality Assurance Project Plan |
| QA | Quality Assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| SOP | Standard Operating Procedure |
| START | Superfund Technical Assessment and Response Team |
| TDD | Technical Direction Document |
| TR | Traffic Report |
| VOC | Volatile Organic Compound |

INTRODUCTION

This document is the site-specific Quality Assurance Project Plan (QAPP) for sample collection and analysis at the Dimock Residential Groundwater Site in Dimock, Pennsylvania, under the Superfund Technical Assessment and Response Team (START) contract in EPA Region 3.

This document will be used in conjunction with TechLaw's Program Quality Assurance Project Plan (PQAPP) for Sample Collection and Analysis for Superfund Technical Assessment and Response Team (START) EPA Region 3, dated July 2010. Additionally, TechLaw's Sampling QA/QC Work Plan (Rev01), dated February 3, 2012 will be used as referenced.

A.1 Project/Task Organization

EPA On-Scene Coordinator Richard Fetzer will provide overall direction to TechLaw (START) staff concerning project sampling requirements, objectives, and schedule.

The TechLaw START 3 Point of Contact (POC) is [REDACTED]. [REDACTED] is the primary contact for contract related matters on START Region 3.

The TechLaw START Site Leader, [REDACTED], is the primary point of contact with the EPA OSC. The Site Leader is responsible for the development and completion of the Sampling QA/QC Work Plan, project team organization, and supervision of all project tasks, including reports and deliverables.

The TechLaw QA Officer, [REDACTED], will remain independent of the groups responsible for data generation. The QA Officer, or his designee will provide QA/QC assistance to the TechLaw Site Leader. The QA Officer will also be responsible for final internal review and approval of the QAPP.

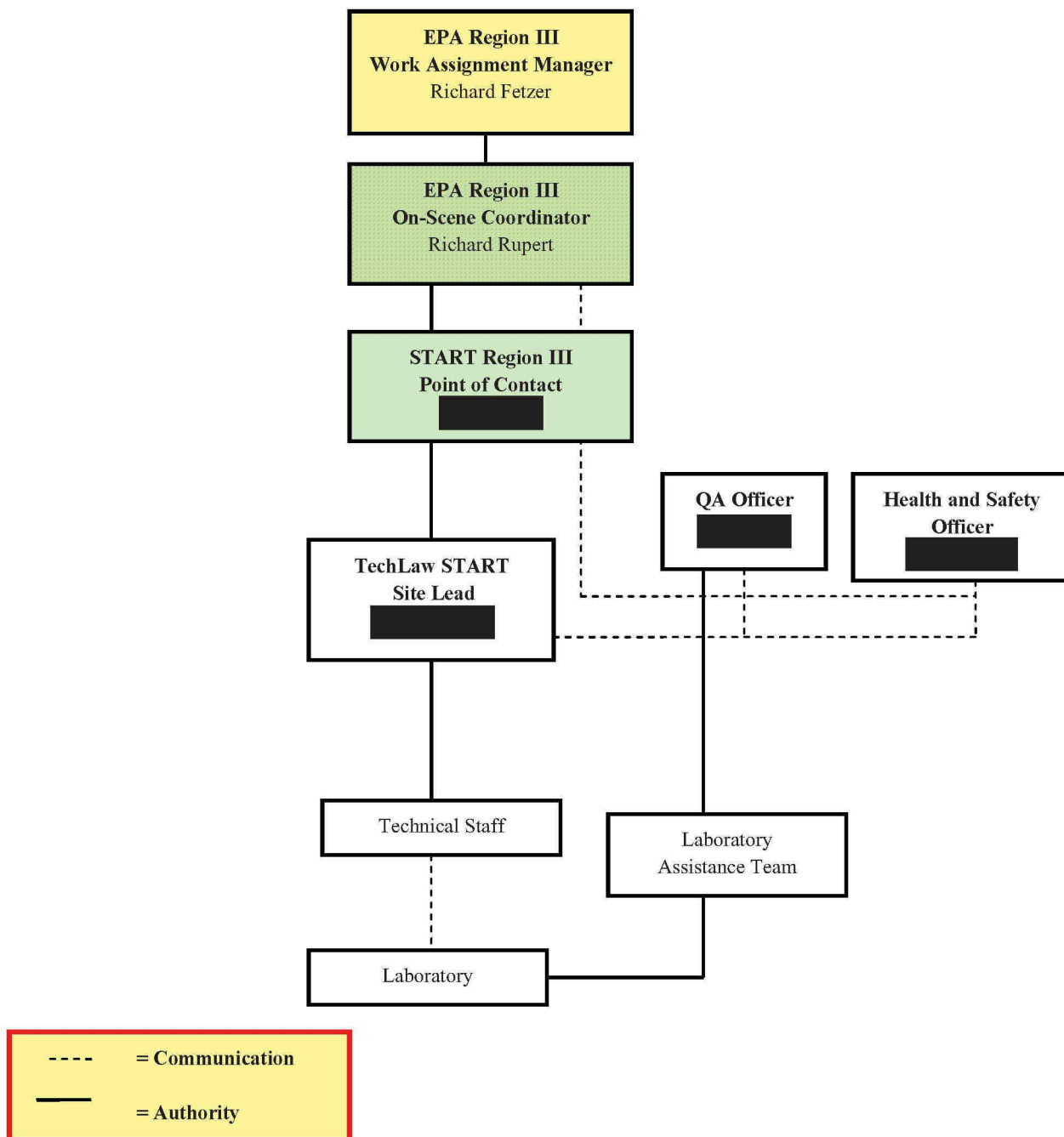
The TechLaw Field Team will conduct the actual field work per this QAPP.

The TechLaw Laboratory Assistance Team (LAT) will coordinate with the analytical laboratories.

The designated laboratories will be responsible for internal control of QA/QC.

Further discussion on project responsibilities can be found in Section A.1.1 and A.1.2 of the PQAPP.

FIGURE A.1
START Region 3 Project Organization



A.2 Problem Definition/Background

The Dimock Residential Groundwater Site (site) is located in the rural community of Dimock Township in northeastern Pennsylvania (pop. 1,497 – 2010 Census). Since 2009, the site has received widespread publicity beginning with reports of methane migration into local domestic water supplies following Marcellus Shale drilling operations in the area. Groundwater sampling activities have also identified the presence of other organic and inorganic contaminants in the private-use wells which may potentially be associated with nonconventional deep shale drilling activities. The origin of the contaminants has not been fully determined.

Privately owned wells constitute the primary source of drinking water for residents in the area. Drilling and production activities involving deep shale gas extraction is prevalent throughout Susquehanna County.

The site includes affected and potentially affected media, namely ground water and surface waters, in the rural area surrounding the intersection of State Route 29 and County Route 2024 in Dimock Township. The coordinates for this location are 41.746411 north latitude, 75.898498 west longitude. Surface waters in the area enter tributaries of Burdick Creek located east/southeast from the site. Burdick Creek flows to Meshoppen Creek also located east/southeast from the site. Meshoppen Creek flows southwest and confluences the Susquehanna River at Meshoppen, PA. Surface water impoundments and/or ponds and lakes are observed in aerial photos to be present near the site. Topographic relief in the vicinity of the site is approximately 400 feet ranging from approximately 1,100 feet to 1,500 feet above mean sea level (amsl). The site is located within the glaciated low plateaus section of the Appalachian Plateaus Province. Surficial bedrock is comprised of the Devonian Catskill Formation having sandstone, siltstone, shale, mudstone and conglomerate lithology.

The Pennsylvania Ground Water Information System database (PAGWIS) identifies 44 ground water withdrawal wells within a 2-mile radius of the site, although more wells are likely to be present. Most of the wells recorded in the PAGWIS are used for domestic purposes. Depths of 19 of these wells are recorded ranging from 125 to 700 feet deep with a median depth of about 250 feet. Yields from 42 of the wells are recorded as ranging from 1-50 gallons per minute (gpm) with a median yield of 13.7 gpm.

A.3 Project/Task Description

On December 19th, 2011, EPA Region III OSC Richard Fetzer tasked TechLaw START to perform a removal site evaluation at the site, located at or near Pennsylvania (PA) Route 29 in Dimock, Susquehanna County, Pennsylvania. The purpose of the assessment is to provide information to EPA to assist in determining if residential home wells have been impacted by

nearby gas well installation and development activities. Sampling activities will include the collection of residential home well groundwater samples. Additionally, surface water samples may be collected if directed by EPA. These sampling activities will be conducted under Technical Direction Document (TDD) No. TL01-11-12-001, START Contract No. EP-S3-10-04.

The objective of the sampling activity is to assess the presence and origin of substances that may present a threat to the health of persons ingesting, contacting or engaging in typical residential or recreational uses of groundwater or surface water. The analytical methods selected are based in part on contaminants that may be present due to the natural gas exploration, drilling or hydraulic fracturing activities located in the region.

A.4 Quality Objectives and Criteria

The purpose of this QAPP is to ensure that the data generated from this sampling event meet the criteria established by EPA Region 3 for precision, accuracy, representativeness, completeness, and comparability (PARCC). The reliability of the analytical data generated depends on the representativeness of the samples collected, the accuracy and completeness of the documentation and record keeping, and the validity and reproducibility of the analytical methods used. Use of accepted EPA methods and sound scientific and engineering principles assure consistent, reliable products that result in a high degree of user satisfaction. The procedures reflected in this QAPP are consistent with EPA accepted methods and other relevant technical standards. TechLaw procedures have been established to assure that the resulting analytical data are defensible legally as well as technically.

A.4.1 Data Quality Objectives

DQOs are qualitative and quantitative statements which specify the quality of the data required to support decisions made during sampling and analysis activities and are based on the end uses of the data to be collected. The following steps are taken in order to determine the appropriate data quality level.

Step 1: State the problem:

Degradation of drinking water and surface water quality from contamination claimed to be associated with Marcellus shale drilling and hydraulic fracturing (a.k.a. fracking) operations has been reported by local private well owners. Privately owned wells constitute the primary source of drinking water for residents in the area.

Step 2: Identify the decision

The decision to be made is to determine whether water samples have been contaminated, and if so, to document the origin of contamination.

Step 3: Identify the input to the decision

Approximately forty to sixty residential home well samples will be collected in the vicinity of Dimock Township. Tap water samples will be collected at homes where access has been granted to EPA officials by property owners. Additionally, it is anticipated that as many as twelve surface water samples may be collected from nearby water bodies.

Step 4: Define the study boundaries

Water samples will be collected within the vicinity of Dimock Township, Susquehanna County, Pennsylvania.

Step 5: Develop a decision rule

Samples will be collected to determine the presence and origin of contamination. The resulting analytical data will be provided to EPA. If contaminants are present above the laboratory method detection limit (MDL), further assessment of the data will be performed by EPA.

Step 6: Specify tolerable limits on decision errors

The data quality objectives are designed to generate data of known quality that meet project needs. Correct sampling and analysis techniques must be followed and resulting data scrutinized. The analytical results from the sampling event are evaluated with respect to the laboratory (Matrix Spike/Matrix Spike Duplicate [MS/MSD], LCS [Laboratory Control Sample], laboratory blanks) and field quality control (QC) samples (i.e., field duplicates, field blanks, equipment blanks, and trip blanks).

Step 7: Optimize the design

Sample locations, as discussed in Step 2, were specified by EPA. Samples will be collected from residential wellheads, residential tap water, and surface water.

A.4.2 Measurement Performance Criteria

Analytical measurements conducted by the designated laboratories are performed in accordance with the quality assurance (QA) procedures detailed in the various methodologies. Laboratory specific information, such as SOPs, QA/QC limits, etc. for the methods to be employed are available upon request.

Further discussion on measurement performance criteria, and PARCC, can be found in the PQAPP.

A.4.3 Decision Rules

A Decision Rule is a statement which allows for a course of action or non-action to be taken, based on assumptions made to draw out and test its logical or empirical consequences.

For the sampling at the Dimock Residential Groundwater Site, samples will be collected to determine the presence and origin of contamination.

A.5 Special Training/Certification

Section A.5 of the PQAPP discusses general training requirements and documentation. Additionally, TechLaw field staff will be required to have attended ICS 100/200 training.

A.6 Documents and Records

Documentation requirements are discussed in Section A.6 of the PQAPP. Project specifics are discussed in Section 8.2 of the Sampling QA/QC Work Plan.

The deliverables to be produced under this project are discussed in Section 10.0 of the Sampling QA/QC Work Plan.

B. DATA GENERATION AND ACQUISITION

The following sections describe the sampling and analysis procedures that will be used to during the investigation.

B.1 Sampling Process Design (Experimental Design)

Residential well samples will be collected in accordance with the EPA Environmental Response Team (ERT) Standard Operating Procedure (SOP) No. 2007 (ERT, 1995). Samples are anticipated to be collected from a valve closest to the well head (wellhead sample) and from the kitchen faucet (tap sample) within each home. Inspection of the water system may be required to identify the appropriate valve sampling location and to determine if it is downstream or upstream of any treatment apparatus. The water samples will be collected simultaneously from the valve closest to the wellhead and the kitchen faucet, after purging procedures are completed and water quality parameters are stabilized as described in Section 7.0 of the Sampling QA/QC Work Plan.

Surface water samples may be collected from locations near the site. The surface water samples will be collected in accordance with ERT SOP No. 2013, utilizing the direct method (ERT, 1994). Surface water sample media will be collected directly into laboratory certified pre-cleaned sample bottles as specified in Table 2 of the Sampling QA/QC Work Plan. All samples will be placed on ice after collection. The analyses to be conducted, as well as the number of samples to be collected, are summarized in Table 1 of the Sampling QA/QC Work Plan.

B.2 Sampling Methods

Methods for collecting residential well samples are discussed in Section 7.1 of the Sampling QA/QC Work Plan. Sampling of surface water is discussed in Section 7.2 of the Sampling QA/QC Work Plan.

B.3 Sampling Handling and Custody

Sample handling and custody procedures are discussed in Section B.3 of the PQAPP as well as Sections 8.2.2, 8.2.3, 8.2.4 and 8.3 of the Sampling QA/QC Work Plan. Site specific sample identification requirements are discussed in Section 7.3 of the Sampling QA/QC Work Plan.

B.4 Analytical Methods

The parameters to be analyzed were specified by EPA.

Table 1 of the Sampling QA/QC Work Plan summarizes the analytical methods and analyses that each laboratory will perform for this investigation. Copies of all TechLaw subcontract laboratory SOPs, laboratory Quality Assurance Plans, reporting limits, method detection limits, and QC acceptance criteria are available upon request.

B.5 Quality Control

QC samples will be collected in the field to assure that measurement objectives are met for laboratory analyses. Field QC samples will consist of one field duplicate for every ten field samples, or one per matrix if fewer than ten are collected. Duplicate samples will be documented in the Field Activities Logbook and on the Traffic Report (TR)/COC. The field duplicate will test the reproducibility of sampling procedures and analytical procedures.

A trip blank will be collected and included in all coolers shipped that contain samples for VOC, Gasoline Range Organics (GRO), and dissolved gas analyses.

A field blank will be collected to ensure the cleanliness of sample containers and to ensure that no cross-contamination has occurred during sample collection, preservation, and shipment, as well as in the laboratory.

An equipment blank will also be collected for any new piece of sampling equipment to be used, on a one-time basis.

Laboratory QC will be performed at the frequencies established in their SOPs. Laboratory, and/or method specified QC limits where applicable, will be used to evaluate the QC results. Corrective action for QC outliers will be handled as per the laboratory QA Plans and applicable SOPs.

Further information on QC can be found in Section B.5 of the PQAPP.

B.6 Instrument/Equipment Testing, Inspection and Maintenance

Section B.6.1 of the PQAPP, and the referenced field SOPs discuss instrument testing, inspection, and maintenance of field instruments/equipment. Dedicated, disposable sampling equipment will be used by TechLaw whenever possible.

Section B.6.2 of the PQAPP presents a general discussion of the testing, inspection and maintenance requirements for laboratory equipment. Laboratory specific procedures are presented in the laboratory SOP and/or QA Plans.

B.7 Instrument/Equipment Calibration and Frequency

Section B.7 of the PQAPP, and the referenced field SOPs discuss general instrument calibration requirements. Laboratory specific procedures are presented in the laboratory SOP and/or QA Plans.

The following equipment will be utilized during sample collection activities and will be calibrated per the manufacturer's instructions:

- YSI 556 MPS water quality meter or equivalent that is equipped with data logging capability and flow-through cell
 - Calibration Schedule:
 - Daily-DO calibration
 - Weekly -pH
 - Monthly -Specific Conductivity and ORP
- HACH 2100Q portable turbidimeter (or equivalent instrument)
 - Calibration Schedule:
 - Daily
- MultiRae Plus
 - Calibration Schedule:
 - Daily - Field Verification
 - Weekly - 5 Sensor Calibration

The following equipment do not require calibration but will be inspected daily prior to use:

- Trimble ProXH or equivalent Global Positioning System (GPS) unit
- HACH titrator (HACH method 8203, equivalent to Standard Method 23208 for alkalinity)
- HACH DR890 spectrometer (HACH method 8146, equivalent to Standard Method 3500-Fe B for wastewater for ferrous iron; HACH method 8131, equivalent to Standard Method 4500-S2-D for wastewater dissolved sulfide)
- Peristaltic Pump

B.8 Inspection/Acceptance of Supplies and Consumables

See Section B.8 of the PQAPP for this information.

B.9 Non-direct Measurements

Prior to any field activities, all written and electronic data and information regarding hazardous characteristics of potential constituents present on-site are retrieved from literature sources. This information will be available to the TechLaw Field Team members prior to sampling activities. This data will provide information on the level of protection needed by the Field Team during field operations. This determination will be made by the site Health and Safety Officer and recorded in the site-specific Health and Safety Plan (HASP).

B.10 Data Management

Section B.10 of the PQAPP presents a discussion of the data management requirements.

Additionally, TechLaw will perform the following data management activities:

- Field data (e.g., field logbooks, groundwater sampling record sheets, internal chain-of-custody forms, etc.) will be retained in the project files and maintained on site for the duration of sampling activities. These records will be scanned and backed up to an external hard drive on a regular basis.
- A hard copy site sample log will be maintained on site and updated on a daily basis. The site sample log will be used to track how many residential homes have been sampled, laboratory and field QC samples collected, as well as pertinent sample collection information (i.e., sample ID, date and time of collection, and field sampler). The site sample log will also be maintained electronically in an Excel file which will be used to track frequency of QC samples collected. The electronic site sample log will also be used to isolate samples by date, etc. to determine the site samples that are associated with respective field QC samples.
- Electronic files containing pertinent information (e.g., SCRIBE database) will be backed up on a daily basis to an external hard drive.
- Digital photographs will be downloaded and saved to an external hard drive on a regular basis.
- GPS data and data-logged water quality parameters from the YSI will be downloaded and saved to an external hard drive on a regular basis.
- TechLaw will receive an electronic Level IV (CLP-equivalent) analytical data package, as well as an electronic data deliverable (EDD), from all Tier IV laboratories. EPA will be carbon copied on the email exchange providing the final analytical reports. Upon receipt, EPA will forward the analytical data to the Region 3 ESAT contractor for data validation.
- It is anticipated that analytical data from the EPA laboratories will be emailed to the EPA Region 3 WAM and OSC. TechLaw will maintain transmitted analytical results in the electronic project files kept on an external hard drive.
- TechLaw has requested EDDs containing validated data. Once received from EPA, TechLaw will upload the validated EDDs into the SCRIBE database.

C. ASSESSMENT AND OVERSIGHT

Section C of the PQAPP presents a discussion of assessments, oversight, responses and corrective action.

C.1 Assessments and Response Actions

No formal internal field audits are planned for the Dimock Residential Groundwater Site sampling event. If a field audit is determined to be necessary (e.g., deviations from this QAPP, the PQAPP, and/or the Sampling QA/QC Work Plan are encountered), or if EPA requests that an audit be performed, TechLaw will follow the procedures outlined in Section C.1.1 of the PQAPP.

The TechLaw Site Lead is responsible for ensuring compliance with all project provisions presented in the QAPP.

System assessments of the designated subcontract laboratories are performed by TechLaw. The procedures for laboratory assessments are discussed in Section C.1.2 of the PQAPP.

If corrective action is found to be necessary after an audit, TechLaw will follow the procedures discussed in Section C.1.3 of the PQAPP.

C.2 Reports to Management

If an audit is performed, an audit report and all necessary corrective actions will be provided to TechLaw management as well as to the EPA personnel copied on this QAPP. See Section C.2 of the PQAPP for additional details on QA reports to management.

Additionally, if directed by EPA, TechLaw will provide a Trip Report describing sampling activities and analytical results to EPA for this project.

D. DATA VALIDATION AND USABILITY

TechLaw will verify data packages from subcontracted laboratories are complete as per the LAT procedures. Details on data verification can be found in Section D of the PQAPP.

Analytical data generated by the EPA OASQA laboratory will be reviewed and validated in accordance with OASQA standard procedures. Other analytical data for organic analyses generated under this Sampling QA/QC Work Plan will be evaluated in accordance with EPA *Region III Modifications to National Functional Guidelines for Organic Data Review Multi-Media, Multi-Concentration (OLMO1.0-OLMO1.9)* (September 1994) to Data Validation Level M2, and in accordance with *EPA Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (April 1993) at the IM2 Level. Validation for the analytical services subcontract arranged through TechLaw will be requested through the EPA ESAT contractor.

Data assessment and reconciliation with user requirements is discussed in Section D.3 of the PQAPP. TechLaw has not been tasked to perform data assessment or evaluation of data usability at this time.

**QUALITY ASSURANCE PROJECT PLAN
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APPENDIX A

**EXAMPLE CHAIN-OF-CUSTODY FORM,
SAMPLE IDENTIFICATION LABEL AND CUSTODY SEALS**

USEPA CLP Generic COC (REGION COPY)

DateShipped: 2/3/2012

CarrierName: FedEx

AirbillNo: 7980 1991 1410

CHAIN OF CUSTODY RECORD

Dimock Residential Groundwater/WV

Case #: CT5865

No: 3-020312-104557-0094

Lab: NAREL

Lab Contact:

Lab Phone: 334.270.3400

| Sample # | Matrix/Sampler | Coll. Method | Analysis/Turnaround | Tag/Preservative/Bottles | Station Location | Collected | Sample Type |
|----------|-------------------------------|--------------|--|--|------------------|------------------|--------------|
| HW40 | Drinking Water/ [REDACTED] | Grab | AlphaSp_Th(7), AlphaSp_U(7), GammaSpec(7), GammaSpec(7), GammaSpec(7), AL_BETA(7), Ra-226(7), Ra-228(7) | 2962 (HNO3 / 1000mlHDPE), 2963 (HNO3 / 1000mlHDPE), 2964 (HNO3 / 1000mlHDPE), 2965 (HNO3 / 1000mlHDPE), 2966 (HNO3 / 1000mlHDPE), 2967 (HNO3 / 1000mlHDPE), 2968 (HNO3 / 1000mlHDPE), 2969 (HNO3 / 1000mlHDPE) (8) | HW40 | 02/02/2012 15:39 | Field Sample |
| HW40-P | Drinking Water/ [REDACTED] | Grab | AlphaSp_Th(7), AlphaSp_U(7), GammaSpec(7), GammaSpec(7), GammaSpec(7), AL_BETA(7), Ra-226(7), Ra-228(7) | 2998 (HNO3 / 1000mlHDPE), 2999 (HNO3 / 1000mlHDPE), 3000 (HNO3 / 1000mlHDPE), 3001 (HNO3 / 1000mlHDPE), 3002 (HNO3 / 1000mlHDPE), 3003 (HNO3 / 1000mlHDPE), 3004 (HNO3 / 1000mlHDPE), 3005 (HNO3 / 1000mlHDPE) (8) | HW40 | 02/02/2012 15:44 | Field Sample |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Special Instructions:

Shipment for Case Complete? N

Samples Transferred From Chain of Custody #

Analysis Key: AlphaSp_Th=10-Alpha Spec, Thorium, AlphaSp_U=10-Alpha Spec, Uranium, GammaSpec=10-Gamma Spec, AL_BETA=10-Gross Alpha/Beta, Ra-226=10-Ra-226, Ra-228=10-Ra-228

| Items/Reason | Relinquished by | Date | Received by | Date | Time | Items/Reason | Relinquished By | Date | Received by | Date | Time |
|--------------|-----------------|--------|-------------|------|------|--------------|-----------------|------|-------------|------|------|
| 16 | [REDACTED] | 2/3/12 | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

EXAMPLE SAMPLE IDENTIFICATION LABEL

Sample: HW41-P **Case:** CT5865
Station Location: HW41
Date: 2/2/2012 Time: 15:54 Grab
Preservation: H2SO4 / 500mlHDPE
Analyses: 07-Phosphorous_NO3-,NO2-,Tot-N
Sampler: [REDACTED] MS/MSD: N
Tag: 3066

EXAMPLE CUSTODY SEALS

| | | | |
|---------------------|---|--|---------------------|
| CUSTODY SEAL |  |  | CUSTODY SEAL |
| _____ Date | | | _____ Date |
| _____ Signature | | | _____ Signature |

**QUALITY ASSURANCE PROJECT PLAN
DIMOCK RESIDENTIAL GROUNDWATER SITE
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APPENDIX B

STANDARD OPERATING PROCEDURES

Standard Operating Procedures List

| <u>SOP Number</u> | <u>Environmental Response Team SOP Title</u> |
|--------------------------|---|
| 2007 | Groundwater Well Sampling |
| 2013 | Surface Water Sampling |
| 2139 | Multi Gas Monitor PGM-50/Photoionization Detector (PID) MultiRae Plus |

| <u>SOP Number</u> | <u>TechLaw SOP Title</u> |
|--------------------------|---|
| 02 05 03 | Field Procedures-Chain-of-Custody |
| 03 01 04 | Field Documentation Procedures-Maintenance of a Field Logbook |
| 03 02 04 | Field Documentation Procedures-Taking and Documenting Photographs |
| 04 02 02 | Packaging and Shipping Procedures-Environmental Samples |



STANDARD OPERATING PROCEDURES

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GROUNDWATER WELL SAMPLING

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- 2.0 METHOD SUMMARY*
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 - 4.1 Well Purging*
 - 4.2 Sampling Equipment*
 - 4.3 Light Non-Aqueous Phase Liquids (LNAPL)*
- 5.0 EQUIPMENT/APPARATUS*
 - 5.1 Bailers*
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 - 7.3.2 Submersible Pumps*
 - 7.3.3 Non-Contact Gas Bladder Pumps*
 - 7.3.4 Suction Pumps*
 - 7.3.5 Inertia Pumps*



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GROUNDWATER WELL SAMPLING

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* These sections affected by Revision 0.0.

SUPERSEDES: SOP #2007; Revision: 0.0; 1/26/95; U.S. EPA Contract EP-W-09-031.



STANDARD OPERATING PROCEDURES

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GROUNDWATER WELL SAMPLING

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) provides general information on sampling groundwater wells and ensures that the sample is representative of the particular groundwater zone being sampled. The growing concern over the past several years with respect to low levels of volatile organic compounds (VOCs) in water supplies has led to the development of highly sophisticated analytical methods that can provide detection limits at part per trillion levels. While the laboratory methods are extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

The procedures are designed for sampling the most common types of groundwater contaminants (e.g., volatile and semivolatile organic compounds, pesticides, herbicides, polychlorinated biphenyls (PCBs), metals, and biological parameters).

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, or equipment limitations and limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

In order to obtain a representative groundwater sample for chemical analysis (es), it is important to remove stagnant water from the well casing and the water immediately adjacent to the well before collection of the sample. This may be achieved with one of a number of sampling devices. The most common of these devices are the bailer, submersible pump, non-contact gas bladder pump, inertia pump and suction pump. At a minimum, three well volumes should be purged, if possible. Equipment must be decontaminated prior to use and between wells. Once purging is completed and the proper sample containers have been prepared, sampling may proceed. Samples should be collected from the depth interval where contaminants are expected but need not be collected with the same device used for well purging. However, some sampling methods will affect sample integrity and care should be taken when choosing the sampling device. If possible, sampling should occur progressively from the least to the most contaminated well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The sample analysis determines the type of bottle, preservative, holding time, and filtering requirements. Samples should be collected directly from the sampling device into appropriate sample containers. Check that a Teflon liner is present in the cap of the sample container, if required. Attach a sample identification label. Complete a field data sheet, a chain of custody form, and record all pertinent data in the site logbook.

Samples should be placed in a cooler and maintained at 4°C and ideally should be shipped within 24 hours of sample collection. If large numbers of samples are being collected, shipments may occur on a regular



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basis after consultation with the analytical laboratory. In all cases, samples should be shipped well before the holding time expires.

Due to the trace levels at which volatile organics are detectable, cross contamination and introduction of contaminants must be avoided. Treatment of the sample with sodium thiosulfate preservative is required only if there is residual chlorine in the water that could cause free radical chlorination and change the identity of the original contaminants. This preservative should not be used if there is no chlorine in the water. Quality assurance/quality control (QA/QC) samples are incorporated into the shipment package to provide a check against cross contamination. Samples for the analysis of volatiles, semivolatiles, pesticides, herbicides and PCBs do not normally require preservation. Groundwater samples for metal analyses should be adjusted with nitric acid to a pH of less than 2. Refer to SERAS SOP# 2003, *Sample Storage, Preservation and Handling*.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The primary goal of well sampling is to obtain a representative sample of the groundwater. Analysis can be compromised by: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. To avoid introducing foreign contaminants into a sample, strict sampling procedures should be followed.

4.1 Well Purging

In a non-pumping well, there will be little or no vertical mixing of the water and stratification will occur. The well water above the screened section will remain isolated and may lack the contaminants representative of the ground water. To avoid collecting unrepresentative water, all monitor wells should be purged of three to five volumes of water prior to sampling. When purging with a submersible pump, the pump intake may be set within the screened interval if evaluation of the well construction, pumping rate, and aquifer characteristics ensures that formation material will not be drawn into the well. Otherwise, the pump should be set just above the top of the screen. Bailers, peristaltic pumps, and miniature submersible pumps can also be used for purging, depending on well depth, groundwater level, and well yield. During purging, the temperature, pH, turbidity, and specific conductivity of the groundwater should be monitored at regular intervals and recorded in the site field logbook. The frequency of monitoring will depend on the purge rate but measurements are generally collected every 5 to 15 minutes. Purging is generally considered complete when these parameters stabilize. Depending on the formation characteristics and the degree of previous development, turbidity may also be a problem. Purging may have to be continued until the turbidity reaches an acceptable level, generally less than 50 nephelometric turbidity units (NTUs).

4.2 Sampling Equipment

The tendency of organics to adsorb or desorb onto or out of many materials makes the selection of sampling materials critical for trace organics analyses. Construction materials for samplers and purging equipment (bladders, pump, bailers, and tubing) should be limited to stainless steel, polytetrafluoroethylene (Teflon), and glass in areas where concentrations are expected to be at or near the detection limit. The use of plastics, such as polyvinyl chloride (PVC) or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation



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equipment as it will not normally come into contact with the sample. Rinsate blanks may be required to check the effectiveness of decontamination procedures when using non-dedicated equipment. In highly contaminated wells, disposable equipment (i.e., polypropylene bailers) may be appropriate to avoid cross-contamination.

4.3 Light Non-Aqueous Phase Liquids (LNAPL)

The presence of floating organic layers in a well may require reevaluation of the sampling plan. There is generally little point in sampling the groundwater directly beneath an organic layer and the presence of both phases complicates the sampling procedure. The organic phase is usually sampled by skimming the top of the liquid column in the well with a bailer or small pump, depending on the viscosity of the liquid.

5.0 EQUIPMENT/APPARATUS

5.1 Bailers

Advantages

- No power source needed
- Portable
- Inexpensive, so it can be dedicated and hung in a well, thereby reducing the chances of cross contamination
- Minimal outgassing of volatile organics while sample is in bailer
- Readily available
- Removes stagnant water first
- Rapid, simple method for removing small volumes of purge water

Disadvantages

- Time-consuming to flush a large well
- Transfer of sample may cause aeration
- The valve at the bottom of the bailer often leaks thus losing some of the sample

5.2 Submersible Pumps

Advantages

- Smaller diameter pumps are usually portable and can be transported from well to well
- Relatively high pumping rates are possible
- Generally very reliable and does not require priming

Disadvantages

- Potential for effects on analysis of trace organics



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- Deep wells may require pumps that are heavy and cumbersome to use
- Expensive
- Power source needed
- Sediment in water may clog intake screen or impellers
- Must be decontaminated between wells

5.3 Non-Contact Gas Bladder Pumps

Advantages

- Maintains integrity of sample
- Easy to use
- Can sample from discrete locations within the monitor well

Disadvantages

- Difficulty in cleaning, although dedicated tubing and bladder may be used
- Only useful to a depth of about 100 feet
- Requires a supply of gas or an air compressor for operation, gas bottles or compressors are often difficult to obtain and are cumbersome
- Relatively low pumping rates

5.4 Suction Pumps (including peristaltic pumps)

Advantages

- Portable, inexpensive, and readily available
- Operates from either 110 VAC or 12 VDC
- Variable flow rate, easily controlled

Disadvantages

- Restricted to wells where water levels are within 20 to 25 feet of the ground surface
- Vacuum can cause loss of dissolved gasses and volatile organics
- Some types must be primed and vacuum is often difficult to maintain during initial stages of pumping
- Generally suitable for only small diameter shallow wells; maximum flow rate of some types (e.g. peristaltic pumps) limited to approximately one gallon per minute (gpm)

5.5 Inertia Pumps

Advantages

- Portable, inexpensive, and readily available
- Offers a rapid method for purging relatively shallow wells



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Disadvantages

- Restricted to areas with water levels within 70 feet of the ground surface
- May be time consuming to purge wells with these manual pumps
- Labor intensive
- WaTerra pumps (for example) are only effective in 2-inch diameter wells

5.6 Field Equipment Checklist

5.6.1 General

- Water level indicator
- electric sounder
- steel tape
- transducer
- reflection sounder
- airline
- Depth sounder
- Appropriate keys for well cap locks
- Steel brush
- HNU or OVA (whichever is most appropriate)
- Logbook (bound)
- Calculator
- Field data sheets and samples labels
- Chain of custody records and seals
- Sample containers
- Engineer's rule
- Sharp knife (locking blade)
- Tool box (to include at least: screwdrivers, pliers, hacksaw, hammer, flashlight)
- Leather work gloves
- Surgical gloves (for sampling)
- Appropriate Health & Safety gear
- Five-gallon pail
- Plastic sheeting
- Shipping containers
- Packing materials
- Bolt cutters
- Ziploc plastic bags
- Containers for evacuation liquids
- Decontamination solutions
- Tap water
- Non phosphate soap
- Pails or tubs



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- Aluminum foil
- Garden sprayer
- Preservatives
- Distilled or deionized water
- Fire extinguisher (if using a generator as a power source)
- In-line filters, 0.45 microns (μm)
- pH meter, temperature meter specific conductivity meter, turbidity meter
- Indelible markers
- Duct tape
- Paper towel
- First aid kit

5.6.2 Bailers

- Clean, decontaminated bailers of appropriate size and construction material
- Unused nylon line, enough to dedicate to each well
- Teflon coated bailer wire
- Sharp knife
- Aluminum foil (to wrap clean bailers)
- Five gallon bucket

5.6.3 Submersible Pumps

- Pump(s)
- Generator (120, or 240 volts) or 12 volt power source, depending on pump
- Extension cords
- PVC coil tubing, diameter suitable for flow requirements
- Hose clamps
- Safety cable
- Tool box
- pipe wrenches
- wire strippers
- electrical tape
- heat shrink wrap or tubing
- hose connectors
- Teflon tape
- Winch, pulley or hoist for large submersible pumps (4-inch diameter or greater)
- Gasoline container, gasoline
- Flow meter and gate valve
- Plumbing components (nipples, reducers, plastic pipe connectors)
- Control box (if necessary)

5.6.4 Non-Contact Gas Bladder Pumps



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- Non-contact gas bladder pump
- Compressor or nitrogen gas tank
- Batteries and charger
- Teflon tubing - enough to dedicate to each well
- Swagelock fitting
- Toolbox supplements - same as submersible pump
- Control box (if necessary)

5.6.5 Suction Pumps

- Pump
- Black PVC coil tubing - enough to dedicate to each well
- Gasoline - if required
- Toolbox
- Plumbing fittings
- Flow meter with gate valve

5.6.6 Inertia Pumps

- Pump assembly (WaTerra pump, piston pump)
- Five gallon bucket

5.6.7 Peristaltic Pumps

- Small diameter "Geotubing"
- Roll of Masterflex tubing
- 110 VAC generator or 12 VDC power source
- Knife, screwdriver

6.0 REAGENTS

Reagents may be used for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed and are summarized in Environmental Response Team/Scientific, Engineering, Response and Analytical Services (ERT/SERAS) SOP #2003, *Sample Storage, Preservation, and Handling*. Decontamination solutions are specified in ERT/SERAS SOP #2006, *Sampling Equipment Decontamination*.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed (i.e., diameter and depth of wells to be sampled).



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2. Obtain necessary sampling and monitoring equipment, appropriate to the type of contaminant being investigated. For collection of volatile organic samples, refer to the work plan to ensure that sufficient 40 milliliter (mL) glass sample vials with Teflon lined septa are available. Check availability of preservatives, packing material, sample labels, and coolers. Trip blanks are incorporated into the shipment package to provide a check against cross contamination.
3. Decontaminate or pre-clean equipment and ensure that it is in working order.
4. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan.
5. Identify all sampling locations.

7.2 Field Preparation

1. Start at the least contaminated well, if known.
2. Lay plastic sheeting around the well to minimize likelihood of equipment contamination from the soil adjacent to the well.
3. Remove locking well cap, note location, time of day, and date in field notebook or appropriate log form.
4. Remove well casing cap.
5. Immediately screen headspace of well with an appropriate air monitoring instrument to determine the presence of volatile organic compounds and record flame ionization detector (FID) or photoionization detector (PID) readings in site logbook.
6. Measure distance from water surface to a reference measuring point and record in site logbook. A reference point may be the top of outer protective casing, the top of riser pipe, the ground surface, or the top of a concrete pad. If floating organics are present, the water level and depth to floating product can be measured with an oil/water interface probe. However, the presence of floating organics will indicate the need to reevaluate the validity of groundwater sampling.
7. Measure total depth of well and record in site logbook or on field data sheet.
8. Calculate the volume of water in the well and the volume to be purged using the calculations in Section 8.0.
9. Select the appropriate purging and sampling equipment.

7.3 Purging



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The amount of purging required before sampling depends on the intent of the monitoring program as well as the hydrogeologic conditions. General assessment of groundwater quality may require long pumping periods to obtain a sample representative of a large volume of the aquifer. The purge volume is determined prior to sampling and the sample is collected after a known volume of the water is pumped from the well, or the well can be pumped until parameters such as temperature, specific conductivity, pH, or turbidity have stabilized. Groundwater quality in the well is considered stabilized after three sets of consecutive readings indicate no change. The time between readings is based on the purge rate and cumulative volume but generally is between 5 to 15 minutes.

Sampling to define a contaminant plume requires a representative sample from a small volume of the aquifer. This requires that the well be purged enough to remove the stagnant water but not enough to induce flow from other areas. Generally, three well volumes are considered sufficient. The total volume purged, purge method, purge rate, and the start and end times of purging are recorded in the field log book.

The following purging devices are most commonly used. Other evacuation devices are available, but have been omitted in this discussion due to their limited use.

7.3.1 Bailers

Bailers are the simplest purging device and generally consist of a rigid length of tube, usually with a ball check-valve at the bottom. A nylon line is used to tie and lower the bailer into the well and retrieve a volume of water. The three most common types of bailers are made of PVC, Teflon, and stainless steel. Purging with bailers is best suited to shallow or small diameter wells. For deep, larger diameter wells that require removal of large volumes of water, pumps may be more appropriate.

Equipment needed will, include a clean decontaminated bailer, Teflon or nylon line, a sharp knife, and plastic sheeting.

1. Determine the volume of water to be purged as described in Section 8.0, *Calculations*.
2. Lay plastic sheeting around the well to prevent contamination of the bailer line with soil or other foreign materials. Do not let the bailer line touch the ground.
3. Attach the line to the bailer and lower into the well until the bailer is completely submerged.
4. Pull bailer out ensuring that the line either falls onto a clean area of plastic sheeting or never touches the ground.
5. Empty the bailer into a container of known volume to determine when the purge volume is reached.



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6. Dispose of purge waters as specified in the work plan.

7.3.2 Submersible Pumps

The use of submersible pumps for purging is permissible provided they are constructed of no contaminating materials. The chief drawback, however, is the difficulty in avoiding cross-contamination between wells. Some pumps can be easily disassembled for cleaning, but field decontamination may be difficult and require solvents that can affect sample analysis. The use of submersible pumps in multiple well-sampling programs, therefore, should be carefully considered against other sampling mechanisms (bailers, bladder pumps). In most cases, a sample can be collected by bailer after purging with a submersible pump; however, submersible pumps may be the only practical sampling device for extremely deep wells (greater than 300 feet of hydraulic head). Under those conditions, dedicated pump systems should be considered to eliminate the potential for cross-contamination of well samples.

Submersible pumps generally use either electric or compressed gas for power. Electric powered pumps can run off a 12 volt direct current (DC) rechargeable battery, or a 110 or 220 volt alternating current (AC) power supply. Gasoline used to power electrical generators is a potential source of contamination and should be kept well away from purging and sampling equipment. Those units powered by compressed air normally use a small electric or gas-powered air compressor. They may also use compressed gas (i.e., nitrogen) from bottles. Pumps are available for monitor wells of various depths and diameters.

The following steps describe the use of submersible pumps in purging a well:

1. Determine the volume of water to be purged as described in Section 8.0, *Calculations*.
2. Lay plastic sheeting around the well to prevent contamination of pumps, hoses or lines with soil or other foreign materials.
3. Assemble pump, hoses and safety cable, and lower the pump into the well. Make sure the pump is deep enough so as not to dewater the pump.
4. Attach flow meter to the outlet hose to measure the volume of water purged or measure with a container of known volume.
5. Use a ground fault circuit interrupter (GFCI) or ground the generator to avoid possible electric shock.
6. Attach power supply, and purge the well until the specified volume of water has been removed (or until field parameters, such as temperature, pH, conductivity, etc, have stabilized). Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, reduce the pumping rate.



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7. Collect and dispose of purge waters as specified in the work plan.

7.3.3 Non-Contact Gas Bladder Pumps

Pumps in this category may be dedicated to a well and include stainless steel and Teflon Middleburg-squeeze bladder pumps such as IEA, TIMCO, Well Wizard or Geolog.

1. Assemble Teflon tubing, pump and charged control box.
2. Procedure for purging with a bladder pump is the same as for a submersible pump (Section 7.3.2).
3. Adjust flow rate to prevent violent movement of the hose as water is drawn in.

7.3.4 Suction Pumps

Suction pumps include centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for relatively rapid purging and can be adjusted to a slower rate for sampling. The peristaltic pump is a low volume pump that uses rollers to squeeze the flexible tubing thereby creating suction. The tubing can be dedicated to a well to prevent cross-contamination. Peristaltic pumps, however, require a power source.

1. Assemble the pump, tubing, and power source if necessary.
2. Procedure for purging with a suction pump is exactly the same as for a submersible pump (Section 7.3.2).

7.3.5 Inertia Pumps

Inertia pumps such as the WaTerra pump and piston pump, are manually operated. These pumps are most appropriate to use when wells are too deep to bail by hand, too shallow or too small in diameter to warrant the use of a submersible pump. The pumps are made of plastic and may either be decontaminated or discarded after use.

1. Determine the volume of water to be purged as described in Section 8.0, *Calculations*.
2. Assemble pump and lower to the appropriate depth in the well.
3. Begin pumping manually, discharging water into a five-gallon bucket (or other graduated vessel). Purge until a specified volume of water has been evacuated (or until field parameters such as temperature, pH, and conductivity, have stabilized).
4. Collect and dispose of purge waters as specified in the work plan.



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7.4 Sampling

Before choosing a sampling device, the advantages or disadvantages of any one device, as outlined in Section 5, should be reviewed. It may be appropriate to use a different device to sample than that which was used to purge. The most common example of this is the use of a submersible pump to purge and a bailer to sample. Samples for volatile organics are collected first when sampling for more than one set of parameters, followed in order by samples for semivolatile organic and inorganic analyses.

7.4.1 Bailers

The positive-displacement sampling bailer is perhaps the most appropriate for collection of water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by well conditions and desired sample depth. A sample is obtained with a bailer using the following steps:

1. Surround the monitor well with clean plastic sheeting.
2. Attach a line to a clean decontaminated bailer. Do not let the line touch the ground.
3. Lower the bailer slowly into the well. Stop lowering when adjacent to the screen or at the desired sample depth
4. Allow bailer to fill and then slowly retrieve the bailer from the well.
5. Remove the cap from the sample container and place it on the plastic sheet or in a location where it will not become contaminated. For VOC sampling precautions, see Section 7.6.
6. Slowly pour the sample from the bailer into the sample container. Any necessary preservative should be added to the sample container before sampling.
7. Repeat steps 3, 4, and 6 as necessary to fill the sample container(s).
8. Cap the sample container tightly and place the prelabeled sample container in a carrier.
9. Replace the well cap.
10. Log the collection time, sampling method, and analyses required for all samples in the site logbook and on field data sheets.
11. Package samples and complete necessary paperwork.

7.4.2 Submersible Pumps



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Submersible pumps are not recommended for sampling but may be used in some situations. The generator and fuel (if needed) used to operate a submersible pump can be a source of contamination and should be kept separate from the sampling containers during transport and downwind during sampling.

1. Allow the monitor well to recharge after purging, keeping the pump just above the screened section.
2. Attach a clean gate valve to the discharge hose (if not already fitted), and reduce the flow of water to a manageable rate.
3. Assemble the appropriate bottles.
4. If a gate valve is not available, run the water down the side of a clean jar and fill the sample bottles from the jar.
5. Cap the sample container tightly and place the prelabeled sample container in a carrier.
6. Replace the well cap.
7. Log all samples in the site logbook and on the field data sheets and label all of the samples.
8. Package samples and complete the necessary paperwork.
9. Transport sample(s) to the decontamination zone for preparation for transport to the analytical laboratory.
10. Upon sampling completion, remove pump and assembly and fully decontaminate the equipment prior to setting it into the next sample well. When possible, dedicate the pump tubing to the well.

7.4.3 Non-Contact Gas Bladder Pumps

Non-contact gas positive displacement bladder pumps are often used when dedicated pumps are required. These pumps are also suitable for shallow (less than 100 feet) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling. Barcelona et al. (1984) and Nielsen and Yeates (1985) report that the non-contact gas positive displacement pumps cause the least amount of alteration in sample integrity as compared to other sample retrieval methods.

1. Allow the well to recharge after purging.



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2. Assemble the appropriate bottles.
3. Turn the pump on, increase the cycle time and reduce the pressure to the minimum that will allow the sample to come to the surface.
4. Non-filtered samples shall be collected directly from the outlet tubing into the sample bottle.
5. For filtered samples, connect the pump outlet tubing directly to the filter unit. The pump pressure should be minimized so that the pressure build up on the filter does not blow out the pump bladder or displace the filter. For the Geotech barrel filter, no actual connections are necessary.
6. Cap the sample container tightly and place the prelabeled sample container in a carrier.
7. Replace the well cap.
8. Log all samples in the site logbook and on the field data sheets, and label all samples.
9. Package samples and complete the necessary paperwork.
10. Transport sample(s) to the decontamination zone for preparation for transport to the analytical laboratory.
11. On completion, remove the tubing from the well and either replace the Teflon tubing and bladder with new dedicated tubing and bladder or rigorously decontaminate the existing materials.

7.4.4 Suction Pumps

Suction pumps are not recommended for sampling because it is operated by a vacuum and could remove volatile organics from the sample.

7.4.5 Inertia Pumps

Inertia pumps may be used to collect samples. It is more common, however, to purge with these pumps and sample with a bailer (Section 7.4.1).

1. Following well evacuation, allow the well to recharge.
2. Assemble the appropriate bottles.
3. Because these pumps are manually operated, the flow rate may be regulated by



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the sampler. The sample may be discharged from the pump outlet directly into the sample container.

4. Cap the sample container tightly and place the prelabeled sample container in a carrier.
5. Replace the well cap.
6. Log all samples in the site logbook and on the field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Upon completion, remove pump and decontaminate or discard, as appropriate.

7.5 Filtering

Samples collected for dissolved metals analysis may require filtration. The filter must be changed or decontaminated between uses. Several types of filters are available. A barrel filter such as the "Geotech" works with a pneumatic (e.g. bicycle) pump, used to build up positive pressure in the chamber containing the sample, which is then forced through the filter paper (minimum size 0.45 μm) into a jar placed underneath. The barrel itself is filled manually from the bailer or directly via the hose of the sampling pump. The pressure must be maintained up to 30 pounds/square inch (lbs/in^2) by periodic pumping.

A vacuum type filter involves two chambers; the upper chamber contains the sample and a filter (minimum size 0.45 μm) divides the chambers. Using a hand pump or a Gillian type pump, air is withdrawn from the lower chamber, creating a vacuum and thus causing the sample to move through the filter into the lower chamber where it is drained into a sample jar. Repeated pumping may be required to drain the entire sample into the lower chamber. If preservation of the sample is necessary, this should be done after filtering.

An in-line filter may be used with a peristaltic pump to transfer the sample from the original sample jar, through the filter, and into a new sample jar. In-line filters are used specifically for the preparation of groundwater samples for dissolved metals analysis, and for filtering large volumes of turbid groundwater. Groundwater samples collected for VOCs are generally not filtered. The filtering of groundwater is performed primarily to allow for the collection of silty or particulate-laden samples that would otherwise interfere with the laboratory analysis. The filters used in groundwater sampling are either cartridge type filters inserted into a reusable housing, or are self-contained and disposable. Disposable filters are preferred and often used to reduce cross-contamination of groundwater samples. Disposable filter chambers are usually constructed of polypropylene material, with an inert filtering material within the housing. Both reusable and disposable filters have barb or national pipe thread (NPT) fittings on the inlet and outlet sides of the housing to connect to $\frac{3}{8}$ " or $\frac{5}{8}$ " tubing.

7.6 Special Considerations for VOC Sampling



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The proper collection of a sample for VOC analysis requires minimal disturbance of the sample to limit volatilization. Sample retrieval systems suitable for collection of volatile organic samples are: positive displacement bladder pumps, gear driven submersible pumps, syringe samplers and bailers (Barcelona et al, 1984; Nielsen and Yeates, 1985). Field conditions and other constraints will limit the choice of appropriate systems. The concern must be to collect a valid sample that has been subjected to the least amount of turbulence possible.

The following procedures should be used:

1. Open the vial, set cap in a clean place, and collect the sample. When collecting duplicates, collect both samples at the same time.
2. Fill the vial to just overflowing. Do not rinse the vial, or let it excessively overflow. There should be a convex meniscus on the top of the vial.
3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap.
4. Invert the vial and tap gently. Observe vial for at least ten (10) seconds. If an air bubble appears, discard the sample and resample. It is imperative that no air is trapped in the sample vial.
5. The holding time for samples to be analyzed for VOCs is seven days. Samples should be shipped or delivered to the laboratory in as short a time as practical in order to arrive before the holding time has expired. Ensure that the samples are stored at 4°C during transport but do not allow them to freeze. The most readily available method of cooling is to use ice packed in double-sealed plastic bags (Ziploc® baggies).

8.0 CALCULATIONS

If it is necessary to calculate the volume of the well, use the following equation:

$$\text{Well Volume (gallons)} = \pi r^2 h k$$

where:

$$\pi = 3.14$$

r = radius of monitor well (feet)

h = height of the water column (feet). This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.

k = conversion factor, 7.48 gallons per cubic foot (gal/ft³)

Monitor well diameters typically have a diameter of 2 to 4 inches. If the diameter of the monitor well is known, standard conversion factors can be used to simplify the equation above.



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The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:

$$V(\text{gal/ft}) = \pi r^2 k \quad \text{or} \quad V = 23.5r^2$$

where:

$$\begin{aligned}\pi &= 3.14 \\ r &= \text{radius of monitoring well (feet)} \\ k &= \text{conversion factor (7.48 gal/ft}^3\text{)}\end{aligned}$$

For a 2-inch diameter well, the volume, in gallons per linear foot, can be calculated as follows:

$$\begin{aligned}V/\text{linear ft} &= \pi r^2 k \\ &= 3.14 (1/12)^2 (7.48 \text{ gal/ft}^3) \\ &= 0.163 \text{ gal/ft}\end{aligned}$$

The well radius must be in feet to be able to use the equation.

The conversion factors (f) for the most common diameter monitor wells are as follows:

| | | | | |
|----------------------|--------|--------|--------|--------|
| Well diameter-inches | 2 | 3 | 4 | 6 |
| Volume (gal/ft.) | 0.1631 | 0.3670 | 0.6528 | 1.4680 |

If you use the conversation factors above, Equation 1 should be modified as follows:

$$\text{Well } V = h e$$

where:

$$\begin{aligned}h &= \text{height of water column (feet)} \\ f &= \text{conversion factor}\end{aligned}$$

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance (QA) activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All sample collection data, including purge methods and time, sample collection methods, times of collection, analyses required, and decontamination procedures (if any) must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration



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must occur prior to purging or sampling and should be done according to the instruction manuals supplied by the manufacturer. All calibration procedures should be documented in the site logbook.

3. The collection of rinsate blanks is recommended to evaluate potential for cross contamination from the purging and/or sampling equipment.
4. Trip blanks are required if analytical parameters include VOCs.

10.0 DATA VALIDATION

This section does not apply to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health Administration (OSHA) or SERAS health and safety guidelines. More specifically, depending upon the site specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

When working around volatile organic contaminants:

1. Avoid breathing volatile constituents venting from the well.
2. Check the well head-space with a FID/PID prior to sampling.
3. If monitoring results indicate organic constituents, it may be necessary to conduct sampling activities in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling:

1. Lifting injuries associated with pump and bailers retrieval; moving equipment.
2. Use of pocket knives for cutting discharge hose.
3. Heat/cold stress as a result of exposure to extreme temperatures in protective clothing.
4. Slip, trip, fall conditions as a result of pump discharge.
5. Restricted mobility due to the wearing of protective clothing.
6. Electrical shock associated with use of submersible pumps is possible. Use a GFCI or a copper



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grounding stake to avoid this problem.

12.0 REFERENCES

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Barcelona, M.J., J.A. Helfrich, E.E. Garske. 1985. "Sampling Tubing Effects on Groundwater Samples." *Analytical Chemistry*. Vol. 57. p. 460-463.

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13.0 APPENDICES

This section does not apply to this SOP.



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SUPERSEDES: SOP #2013; Revision 0.0; 11/17/94; U.S. EPA Contract EP-W-09-031.



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SURFACE WATER SAMPLING

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) is applicable to the collection of representative surface water samples from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Sampling situations vary widely; therefore, no universal sampling procedure can be recommended. However, surface water sampling is generally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- Van Doren sampler
- Bacon bomb sampler
- Dip sampler
- Direct method

These samplers and sampling techniques will result in the collection of representative samples from the majority of surface waters and impoundments encountered.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, the following procedures should be followed:

1. Transfer the sample(s) into suitable, labeled sample containers specific for the analyses to be performed.
2. Preserve the sample, if appropriate, or use pre-preserved sample bottles. Do not overfill bottles if they are pre-preserved.
3. Cap the container securely, place in a resealable plastic bag, and cool to 4°C.
4. Record all pertinent data in the site logbook and/or on field data sheets.
5. Complete the Chain of Custody record.
6. Attach custody seals to cooler prior to shipment.



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7. Decontaminate all non-dedicated sampling equipment prior to the collection of additional samples.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems associated with surface water sampling. These include cross contamination of samples and improper sample collection.

1. Cross contamination problems can be eliminated or minimized through the use of dedicated or disposable sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to ERT/SERAS SOP #2006, *Sampling Equipment Decontamination*.
2. Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed or non-representative area.

Following proper decontamination procedures, minimizing disturbance of the sample site, and careful selection of sampling locations will eliminate these problems. Proper timing for the collection of samples must be taken into consideration due to tidal influences and low or fast-flowing streams or rivers.

5.0 EQUIPMENT/APPARATUS

Equipment needed for collection of surface water samples may include (depending on technique chosen):

- Kemmerer bottles
- Van Doren sampler
- Bacon bomb sampler
- Dip sampler
- Line and messengers
- Peristaltic pump
- Tygon tubing
- 0.45 micron (μm) filters
- Sample bottles/preservatives
- pH paper
- Resealable plastic bags
- Ice
- Coolers, packing material
- Chain of Custody records, custody seals
- Field data sheets
- Decontamination equipment/supplies
- Maps/plot plan
- Safety equipment
- Compass
- Tape measure
- Survey stakes, flags, or buoys and anchors
- Camera and film



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- Logbook/waterproof pen
- Sample bottle labels
- Paper towels
- Disposable pipets
- Hydrolab

6.0 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed and are summarized in ERT/SERAS SOP #2003, *Sample Storage, Preservation and Handling*. Decontamination solutions are specified in ERT/SERAS SOP #2006, *Sampling Equipment Decontamination*.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
2. Obtain the necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry, in accordance with the site specific Health and Safety Plan (HASp).
6. Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and obstructions.

7.2 Representative Sampling Considerations

In order to collect a representative sample, the hydrology and morphometrics of a stream, river, pond, lake or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in ponds, lakes and impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, conductivity, oxidation-potential, temperature and turbidity can indicate if strata exist that would affect analytical results. Measurements should be collected at one-meter intervals from the surface to the bottom using the appropriate instrument (i.e., a Hydrolab or equivalent). These water quality measurements can assist in the interpretation of analytical data, and the selection of sampling sites and depths when



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surface water samples are collected.

Factors that contribute to the selection of a sampling device used for sampling surface waters in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

- Width, depth, flow and accessibility of the location being sampled
- Whether the sample will be collected onshore or offshore

7.2.1 Sampler Composition

The appropriate sampling device must be of a proper composition. Selection of samplers constructed of glass, stainless steel, polyvinyl chloride (PVC) or PFTE (Teflon) should be based upon the suspected contaminants and the analyses to be performed.

7.3 Sample Collection

7.3.1 Kemmerer Bottle

A Kemmerer bottle (Figure 1, Appendix A) may be used in most situations where site access is from a boat or structure, such as a bridge or pier, and where samples at specific depths are required. Sampling procedures are as follows:

1. Use a properly decontaminated Kemmerer bottle. Set the sampling device so that the upper and lower stoppers are pulled away from the body, allowing the surface water to enter tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid disturbance of the bottom.
3. When the Kemmerer bottle is at the required depth, send the weighted messenger down the suspension line, closing the sampling device.
4. Retrieve the sampler and discharge the first 10-20 milliliters (mL) from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

7.3.2 Van Doren Sampler

A Van Doren sampler (Figure 2, Appendix A) is used to collect surface water from a very specific sampling depth or from a shallow water body. Since the sampler is suspended horizontally, the depth interval sampled is the diameter of the sampling tube. The sampling procedure is as follows:

1. Use a properly decontaminated Van Doren sampler. Set the device so that the end stoppers are pulled away from the body allowing surface water to enter the



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tube.

2. Lower the pre-set sampling device to the predetermined depth. Avoid disturbance of the bottom.
3. When the Van Doren is at the required depth, send the weighted messenger down the suspension line, closing the sampling device.
4. Retrieve the sampler and discharge the first 10-20 milliliters (mL) from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

7.3.3 Bacon Bomb Sampler

A bacon bomb sampler (Figure 3, Appendix A) may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut. This will allow the sampler to fill.
2. Release the trigger line and retrieve the sampler.
3. Discharge the first 10-20 milliliters (mL) from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

7.3.4 Dip Sampler

A dip sampler (Figure 4, Appendix A) is useful in situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.
2. Extend the device to the sample location and collect the sample by dipping the sampler into the water.
3. Retrieve the sampler and transfer the sample to the appropriate sample container(s).

7.3.5 Direct Method



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For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples directly into the sample container(s). Health and safety considerations must be addressed when sampling lagoons or other impoundments where specific conditions may exist that warrant the use of additional safety equipment. These issues must be addressed in the site-specific HASP.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream; the container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface while avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.
3. To avoid the incidental inclusion of disturbed sediment in the sample, surface water should be collected from a downstream to upstream direction and upstream of any activity that may disturb the sediment (i.e., wading).
4. While collecting surface water using the direct method, the sample container should be held below the surface to avoid the collection of floating debris.
5. Water quality data should be collected to detect the presence of stratified layers or other site-specific characteristics that would affect the sample.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY



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When working with potentially hazardous materials, follow U.S. EPA, Occupational Health and Safety (OSHA) and corporate health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, adequate health and safety and boating precautions must be taken to ensure the safety of sampling personnel.

12.0 REFERENCES

Wilde, F.D., D.B. Radtke, J. Gibbs and R.T. Iwatsubo. 1998. National Field Manual for the Collection of Water-Quality Data - Selection of Equipment for Water Sampling. U.S. Geological Survey Techniques of Water - Resources Investigations, Book 9, Chap. A2, variously paged.

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U.S. Environmental Protection Agency. 1984. Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition. EPA/600/4-84-076.

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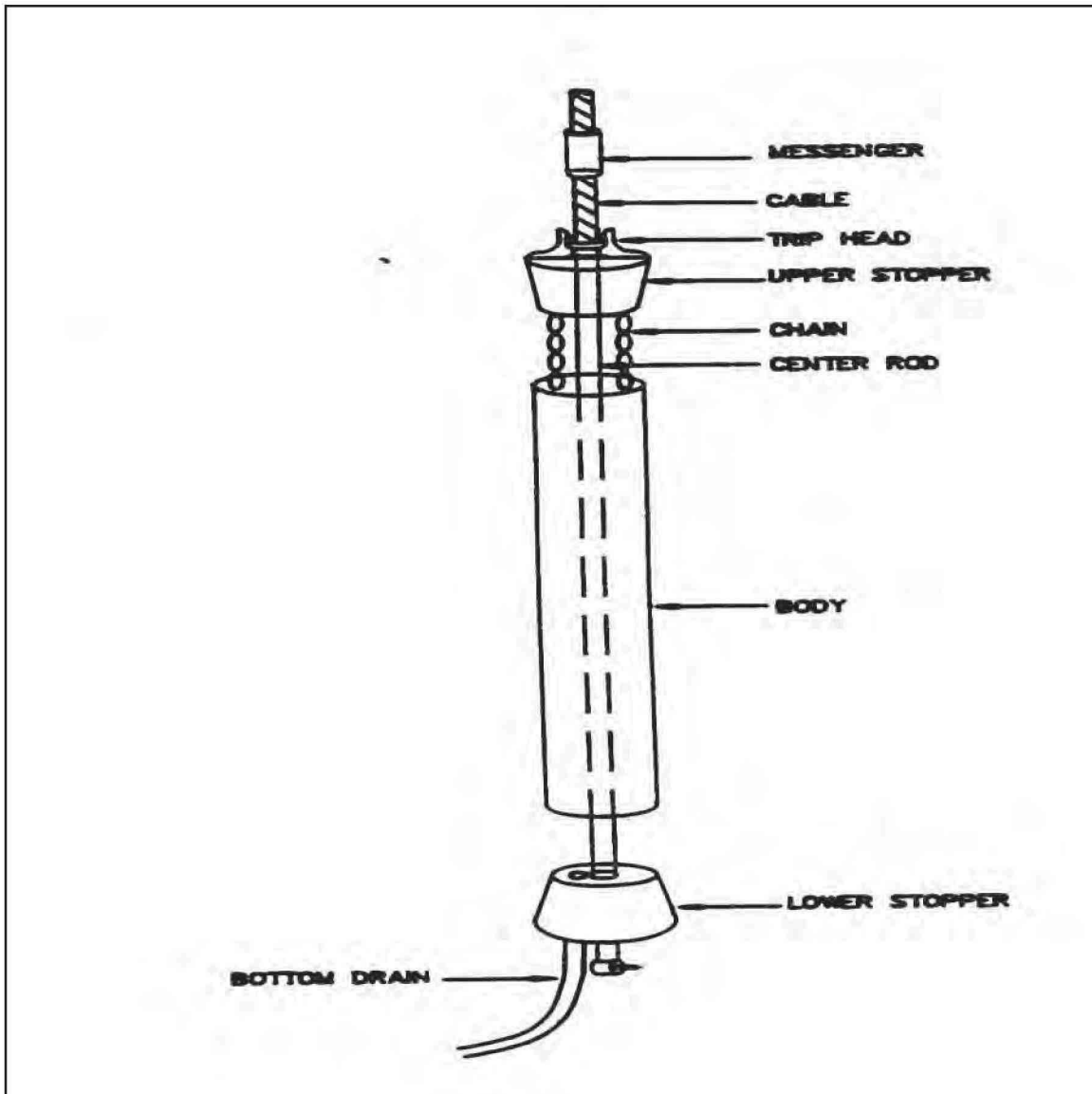


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FIGURE 1. Kemmerer Bottle



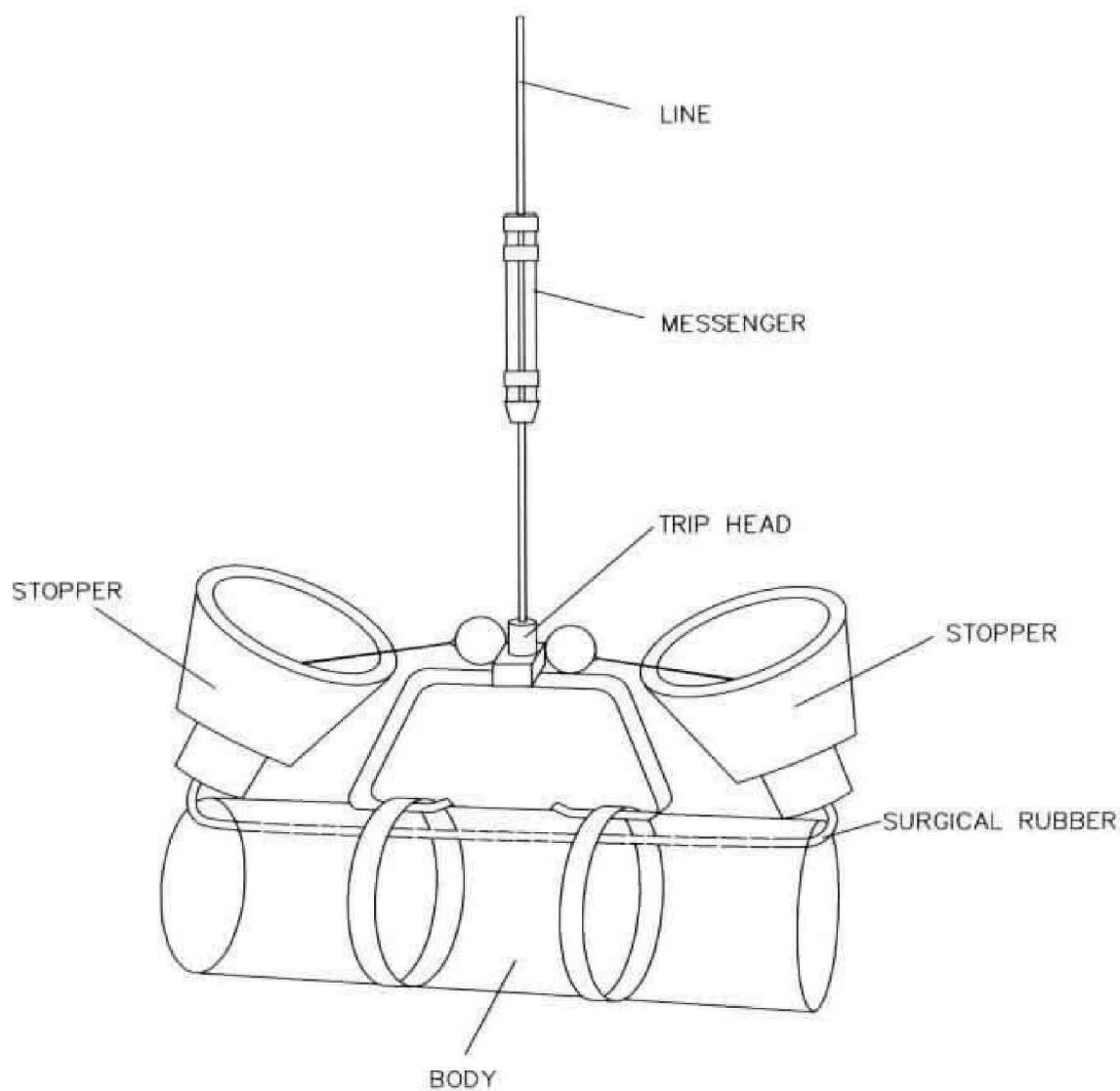


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FIGURE 2. Van Doren Sampler



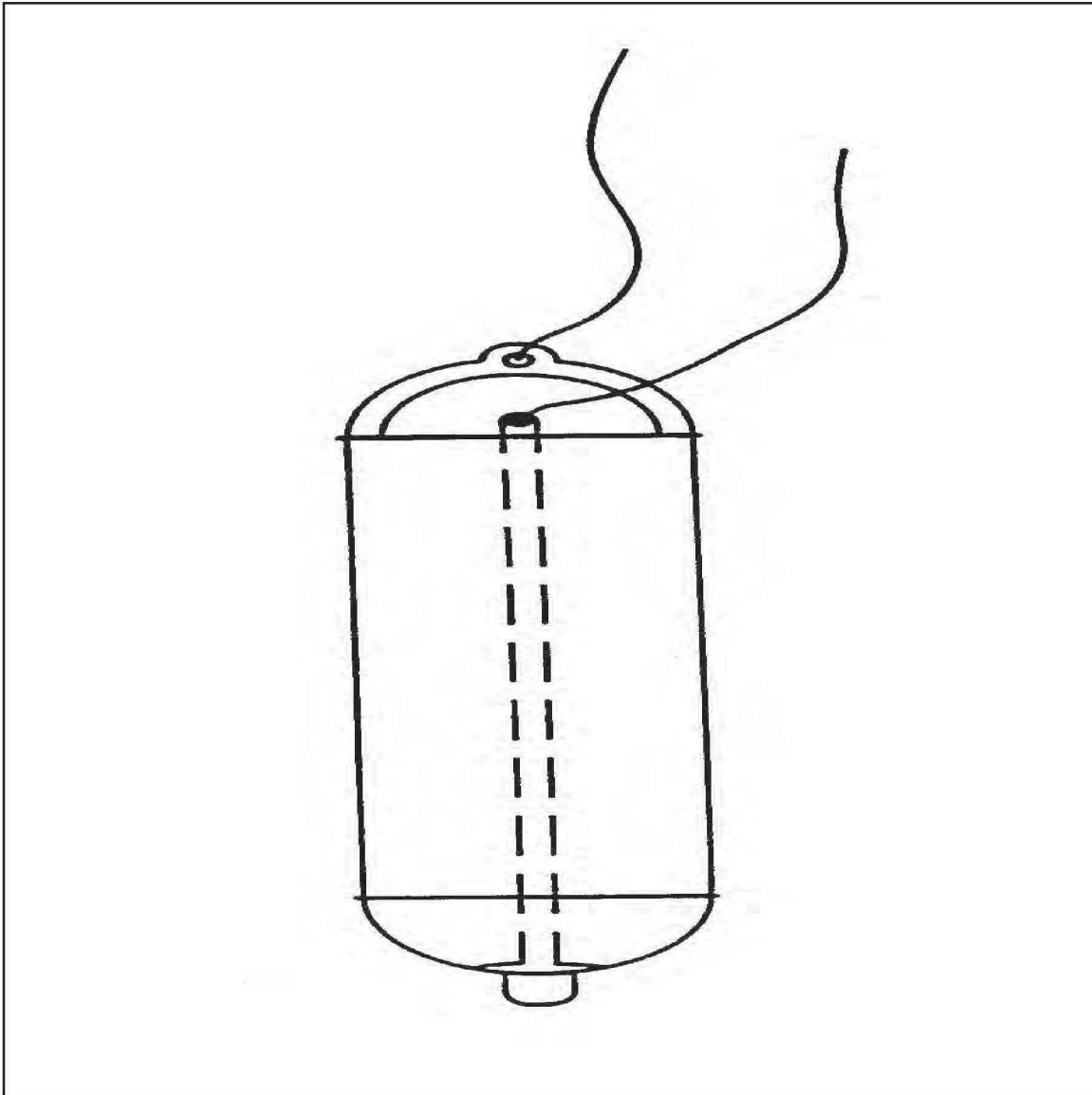


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FIGURE 3. Bacon Bomb Sampler



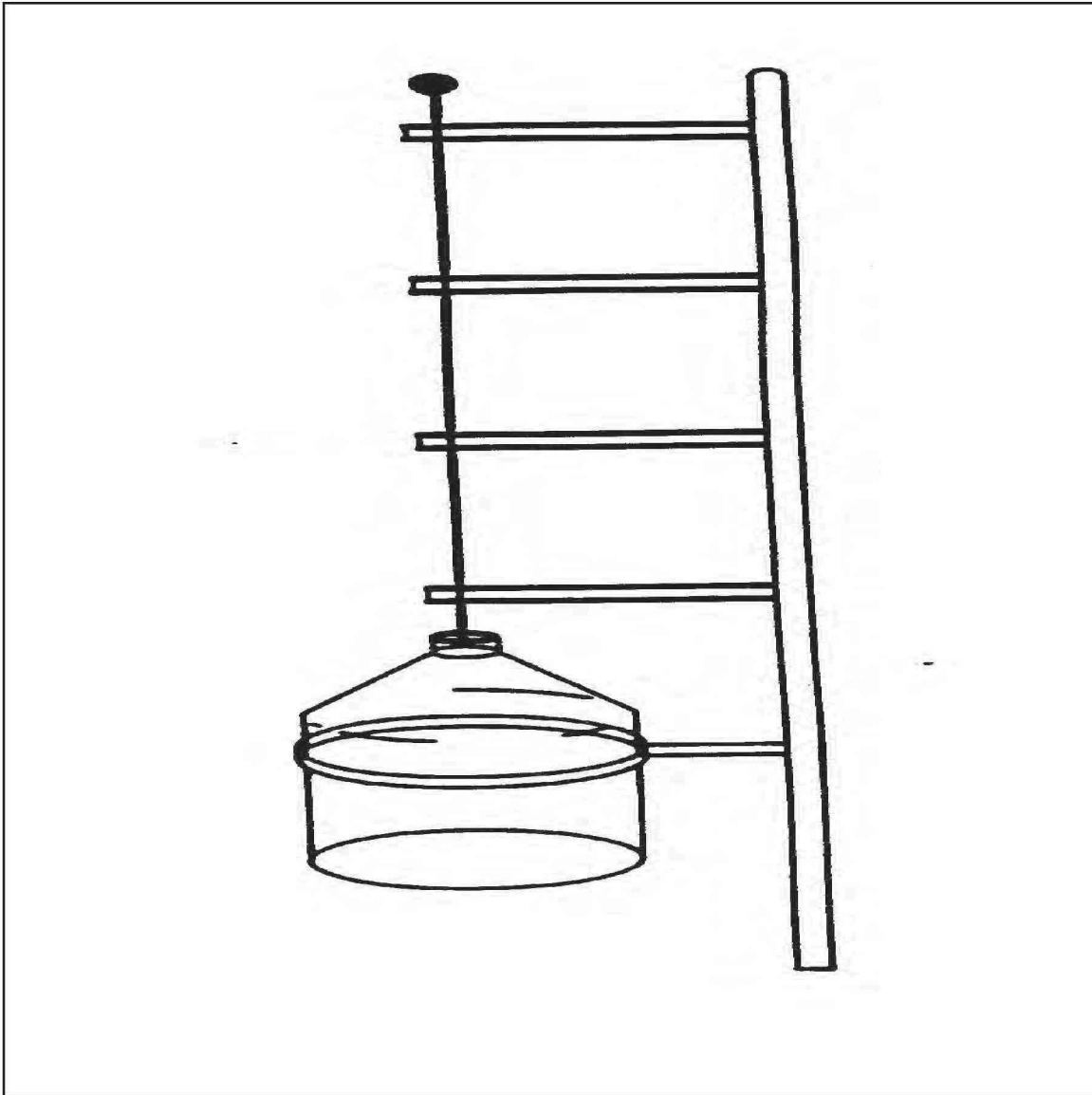


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FIGURE 4. Dip Sampler





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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for using the Multi Gas Monitor PGM-50 Photo-Ionization Detector MultiRAE Plus (hereinafter called the MultiRAE Plus). The MultiRAE Plus is a portable, nonspecific, vapor/gas detector employing the principle of Photo-Ionization and a combination of electrochemical sensors to measure a variety of organic vapors in parts per million (ppm), oxygen (O_2) concentration in percent by volume (vol%) and combustible gases near their explosive limit (LEL) in percentage, and up to two inorganic toxic gases in ppm.

2.0 METHOD SUMMARY

The MultiRAE Plus is a useful general survey instrument at hazardous waste sites, capable of detecting and measuring real-time concentrations of many organic and inorganic vapors in air. The MultiRAE Plus is similar to a flame ionization detector (FID) in application; however, the MultiRAE Plus has somewhat broader capabilities in that it can detect certain inorganic vapors, oxygen levels, and specific toxics. Conversely, the MultiRAE Plus is unable to respond to certain low molecular weight hydrocarbons, such as methane and ethane that are readily detected by FID instruments.

The MultiRAE Plus will respond to most vapors that have an ionization potential less than or equal to that supplied by the ionization source, which is an ultraviolet (UV) lamp. Photo-ionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and form a positive ion. This will occur when the ionization potential of the molecule measured in electron volts (eV) is less than the energy of the photon. Though it can be calibrated to a particular compound, the instrument cannot distinguish between detectable compounds in a mixture of gases and, therefore, provides an integrated response to the mixture.

Two lamps, each containing a different UV light source, with energy levels of 10.6 and 11.7 eV, are available for use with the MultiRAE Plus. Both detect many aromatic and large molecular hydrocarbons, some smaller organic molecules, and some halogenated hydrocarbons.

Gases with ionization potentials near to or less than that of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials higher than that of the lamp will not be detected. Ionization potentials for various atoms, molecules, and compounds are provided in Table 1 (Appendix A). The ionization potential of the major components of air (O_2 , nitrogen, and carbon dioxide) range from about 12.0 eV to about 15.6 eV and are not ionized by either of the two lamps.

The MultiRAE Plus contains a protected catalytic bead for measuring combustible gases as a percentage of their LELs, and interchangeable electrochemical sensors for measuring oxygen and up to two toxic gases. The two plug in "smart" toxic sensor ports may be configured for: carbon monoxide (CO), hydrogen sulfide (H_2S), sulfur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), chlorine (Cl_2), hydrogen cyanide (HCN), ammonia (NH_3), phosphine (PH_3), and ethylene oxide (ETO). The NO, ETO or NH_3 toxic sensors require a special 300 millivolt (mV) bias voltage to operate. Only the first toxic sensor socket provides such a special bias voltage.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.



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4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 MultiRAE Plus Instrument Limitations

- The PID is a nonspecific total vapor detector. The PID cannot distinguish one ionizable gas from another. If there is more than one compound present, it will not give an accurate reading of a specific gas, the reading will be an approximate reading of the total gas concentration.
- The MultiRAE Plus must be calibrated to a specific compound.
- The MultiRAE Plus does not respond to certain low molecular weight hydrocarbons, such as methane and ethane. If the ionization energy (IE) of a compound is higher than that of the UV lamp, it cannot be measured by the PID.
- High humidity level and the presence of other non-ionizable gas such as methane at 10 vol% can reduce the sensitivity of the PID. These effects can be reduced with the use of membrane filters.
- When volatile organic compound concentrations are greater than a few thousand ppm the PID will lose accuracy, and become over saturated. Some of the gas molecules will be blocked from the UV lamp and therefore will not be ionized.
- This instrument cannot to be exposed to precipitation (rain) and can only operate in temperatures between - 4 degrees and 113 degrees Fahrenheit.
- Do not use this instrument for head space analysis where liquids can inadvertently be drawn into the probe.
- The high pump setting is required for vapors that are especially reactive or absorb easily to instrument surfaces. Vapors include CL_2 , PH_3 , NH_3 , HCN , and semi-volatile organic compounds like diesel fuel and jet fuels. Removal of the filter will increase the pump speed to about three hundred (cc/min.)

4.2 Regulatory Limitations

Transport of calibration gas cylinders by passenger and cargo aircraft must comply with International Air Transport Association (IATA) Dangerous Goods Regulations or the U.S. Code of Federal Regulations, 49 CFR Parts 100-177. A typical calibration gas included with a MultiRae Plus is isobutylene or RAE multi gas mix. It is classified as a non-flammable gas, UN #1556, and the proper shipping name is Compressed Gas. It must be shipped by cargo aircraft only.

5.0 EQUIPMENT/APPARATUS

The following equipment is required for MultiRAE Plus operation:

- MultiRae Plus
- Operating manual
- Lamps: 10.6 eV, or 11.7 eV



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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

- Battery charger for MultiRAE Plus
- Spare batteries
- Teflon tubing
- Isobutylene or RAE multi-gas calibration gas
- "T" valve for calibration
- Field Data Sheets/Site Logbook
- Rubber boot with belt clip
- Calibration regulator
- Water trap adapter
- Water trap filters
- Inlet probe 3 inch
- Strap for carrying MultiRAE Plus
- Teflon tubing for downhole measurements
- Carbon filters

NOTE: Battery charge status - This instrument may be kept on continuous charge without battery damage. The unit can be used while simultaneously charging.

6.0 REAGENTS

- Isobutylene standards for calibration
- RAE multi-gas calibration
- Mild soap solution for cleaning unit surfaces
- Specific gas standards when calibrating to a specific compound

The MultiRAE Plus is calibrated in accordance with the operations manual using isobutylene or RAE multi-gas as the calibration standards. The operations manual may also be referred to for alternate calibration to a specific compound.

7.0 PROCEDURES

7.1 Preparation

Check out and ensure the proper operation of the MultiRAE Plus, as appropriate, using the equipment checklist provided in Sections 5.0 and 6.0 and the steps listed below.

7.2 Start-Up Procedures

1. To turn the unit on press and release the [MODE] key. Allow the unit to warm up for 60 seconds.
2. The monitor will display the preset alarm limits for each sensor, the battery voltage, the user mode, the alarm mode, the available data storage memory (in hours), the data mode, and the datalog interval (in seconds). After 10 seconds, the display will show the instantaneous reading of the gas concentration in ppm and is ready to monitor.
3. Oxygen should read 20.9% and all other numbers should read 0. If any sensors are not correct, perform a fresh air calibration (refer to section 7.3.1 Field Calibration).



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4. To zero the instrument, Press the [Y/+] key at the “Fresh air calibration?” prompt.

7.3 Field Operation

7.3.1 Field Calibration

1. Follow the start-up procedure in Section 7.2.
2. Enter the program mode by pressing and holding both the [N/-]key and [MODE] key for three seconds. The first menu item displayed will be “Calibrate Monitor?”, press the [Y/+] to enter the calibration mode.
3. If asked for a password, use [Y/+] and [N/-] keys to set the digits of the password, and the [MODE] key to move the cursor. Hold the [MODE] for one second when done.
4. In calibration mode check the “Modify Span Gas Value?” by pressing the [Y/+] key.
5. If the span gas values are correct (calibration gas concentration and span are set at the same ppm value) press and hold the [MODE] key to continue calibrating. If a span needs to be changed, press the [Y/+] and [N/-] keys to change the digit value; press the [MODE] key momentarily to switch from one digit to the next. When completed press and hold the [MODE] key for one second to save the new calibration gas value.
6. Press the [Y/+] key to “Calibrate monitor?”
7. For the fresh air calibration first press the [Y/+] key at the “Fresh air calibration?” prompt. You must be in a clean air environment, to continue the calibration. If you are not in a clean environment, a “zero” air bottle can be attached to the inlet port to continue the calibration.
8. For the multiple sensor calibration press the [Y/+] key at the “Multiple sensor calibration?” prompt.
9. To calibrate all the sensors shown in the display, apply the gas by attaching a tube from the regulator on the calibration bottle to the inlet port on the monitor, and press the [Y/+] key. To change the sensor selection, press the [N/-] key, then use the [MODE] key to position the cursor, the [Y/+] key to select a sensor, and the [N/-] key to deselect a sensor. Connect the gas and then hold the [MODE] key to start the calibration.
10. For a single sensor calibration press the [Y/+]key to “Single sensor calibration?” prompt, use the [MODE] key to select a sensor, connect the gas, and then press the [Y/+]key to start the calibration.



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11. Upon completion of the calibration record the following information in the site logbook: the instrument identification (ID) number (U.S. EPA decal or serial number if the instrument is a rental), the date and time, the concentration of and the type of calibration gas used, and the name of the person who field calibrated the instrument.

7.3.2 Operation

The MultiRAE has three different modes of operation: the text mode, the display mode, and the programming mode (the default).

1. In the text mode the monitor will display the sensor name after the monitor is turned on. The [MODE] key can then be used to see the instantaneous gas concentration reading, the battery voltage, and to enter the personal computer (PC) menu. The user can also get to the calibration mode from the text mode to calibrate the monitor.
2. In the display mode, the MultiRAE Plus is able to display all the information in the text mode. Additional options available by depressing the [MODE] key:
 - Peak - the highest reading of gas concentration since the monitor was turned on
 - Minimum- the lowest reading of each gas concentration since the monitor was turned on
 - Short term exposure level (STEL)- the last 15 minute average reading of the gas concentration
 - Time weighted average(TWA)- the accumulated reading of the gas concentration divided by 8 hours since the monitor was turned on
 - Run time- in hours and minutes
 - Temperature- in degree Celsius (°C)
 - Datalog mode(or enable/disable datalogging operation in manual datalog mode)
 - LEL/VOC gas names
 - Printing and communication with a PC options
 - The user will not be able to calibrate or change parameters from the display mode.
3. In the programming mode which is, the default setting, the user may perform all the functions of the MultiRAE Plus.
4. Under no circumstances should the probe tip assembly be immersed in fluid.
5. While taking care to prevent the MultiRAE Plus from being exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site Health and Safety Plan. The MultiRAE Plus survey should be conducted at a slow to moderate rate of speed and the intake



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assembly (the probe) slowly swept from side to side. There is a three to five second delay in read-out depending upon the instruments sensitivity to the contaminant.

6. When the activity is completed, or at the end of the day, carefully clean the outside of the MultiRAE Plus with a damp disposable towel to remove any visible dirt.

7.4 Data Logging

The MultiRAE Plus calculates and stores gas readings based on a user-specified datalogging period and the type of measurements. Average or peak measurements can be stored for each sensor during each datalogging interval. The datalogging interval can be set from one second to 60 minutes in one-second increments. In addition, time stamp, user ID, site ID, serial number, last calibration date, and alarm limits are stored. All data is retained in anon-volatile memory, which can be downloaded to a PC.

7.4.1 Datalog Options

1. Automatic: start and stop datalogging automatically when the monitor is turned on and off.
2. Manual: start and stop datalogging by pressing the key manually. There is a timer available to setup the maximum datalog time.
3. Periodic: start and stop datalogging daily based on a preset time (hour and minute).
4. Schedule: start and stop datalogging based on a preset date and time (month, date, hour, and minute).

7.4.2 Datalog start/stop

If the manual datalogging option has been selected from the menu, toggle through the menu using [MODE] key until "Start Datalog?" prompt is displayed.

1. Pressing the [Y/+] key turns on datalogging.
2. Pressing the [Y/+ key a second time will stop the datalogging.

All other datalogging options will stop and start automatically.

7.5 Post Operation

1. To turn off the monitor press and hold the [MODE] key for 5 seconds. The monitor will beep once per second during the power- down sequence. The message "Off!.." flashes on the screen and then the screen goes blank.
2. Turning the monitor off with the AC charger in place will result in a display of



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“Charging...” or “Battery Charged”. This means the unit is off, but the smart charger circuit is now active.

3. Check the equipment, repair or replace damaged equipment, and charge the batteries.

8.0 CALCULATIONS

The MultiRAE Plus can be used for the detection of a wide variety of gases that exhibit different responses. Any compound with IE lower than that of the lamp photons can be measured. The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. Correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. Correction factors can be used in three ways:

1. Calibrate the monitor with isobutylene to read in isobutylene equivalents. Manually multiply the reading by the correction factor to obtain the concentration of the gas being measured.
2. Calibrate the monitor with isobutylene to read in isobutylene equivalents. Call up the correction factor (see steps below) from the instrument memory or download it from a computer. The monitor will then read directly in units of the gas of interest.

Under the “Sensor Configuration Sub-Menu” select “Change LEL/VOC Gas Selection?”, by pressing the [mode] key.

Press the [Y/+] key. If the LEL sensor is installed and enabled, the display shows: [LEL Gas = ? ethane]

Otherwise, the message “No LEL installed” will be displayed and skip to Step 8.

If the user does not want to change the LEL measurement gas, press the [Y/+] key to accept the current gas and skip to Step 6.

If the user wants to modify the LEL measurement gas, press the [N/-] key first, then use the [Y/+] or the [N/-] key to scroll through a list of gas names until the desired gas name appears in the LCD display, then press the [MODE] key to select the new gas name.

The display shows “Save new gas?” To confirm the new gas, press the [Y/+] key to accept the change. Press the [N/-] key or the [MODE] key to discard the change and move to the next step.

Display shows: [methane LEL factor=1.00?], where “1.00” is the calculated correction factor of the selected gas in Step 4.

If the user does not want to modify the LEL correction factor, press the [Y/+] key and go to Step 8. To modify this factor, press the [N/-] key first. Then starting from the left-most digit, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. Repeat this process until all 4 digits of the new factor are entered. Press and hold the [MODE] key for 1 second to exit the data entry mode. If there is any change to the existing value, the display shows “Save?” Press the [Y/+] key to accept the new value and exit the gas selection sub-menu. Press the [N/-] key to discard the changes.



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If the VOC sensor is installed and enabled, the display will show: [VOC Gas=? Isobutylene]

Otherwise, the message “No VOC installed” will be displayed and move to the next sub-menu.

If the user does not want to change the VOC measurement gas, press the [Y/+] key to accept the current gas and skip to Step 12.

If the user wants to modify the VOC measurement gas, press the [N/-] key first, then use the [Y/+] or the [N/-] key to scroll through a list of gas names until the desired gas name appears in the LCD display, then press the [MODE] key to select the new gas name.

The display shows “Save new gas?” To confirm the new gas, press the [Y/+] key to accept the change. Press the [N/-] key or the [MODE] key to discard the change and move to the next step.

Display shows: [methane VOC factor=1.00?], where “1.00” is the calculated correction factor of the selected gas in Step 10.

If the user does not want to modify the VOC correction factor, press the [Y/+] key and go to Step 8. To modify this factor, press the [N/-] key first. Then starting from the left-most digit, use the [Y/+] or [N/-] key to change the digit value and press the [MODE] key momentarily to advance to the next digit. Repeat this process until all 4 digits of the new factor are entered. Press and hold the [MODE] key for 1 second to exit the data entry mode. If there is any change to the existing value, the display shows “Save?” Press the [Y/+] key to accept the new value and exit the gas selection sub-menu. Press the [N/-] key to discard the changes.

3. Calibrate the monitor with isobutylene, but input an equivalent, “corrected” span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

The list of correction factors and IEs is provided in Table 1.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY



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When working with potentially hazardous materials, follow U.S. EPA, OSHA, or corporate health and safety practices.

12.0 REFERENCES

RAE Systems, Inc. 2000. "Operation and Maintenance Manual." (Document No: 008-4001) Rev. F

U.S. Code of Federal Regulations, 49 CFR Parts 100 to 177, Transportation, revised November 1, 1985.

U.S. Environmental Protection Agency. 1984. "Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods, Second Edition", EPA-600/4-84-076, Environmental Monitoring Systems Laboratory, Office of Research and Development, Las Vegas, Nevada.

International Air Transport Association Dangerous Goods Regulations



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TABLE 1. Correction Factors and Ionization Energies

Technical Note TN-106

Revised 12/2007

| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (eV) | TWA |
|---|---|------------|--|------|---|------|---|------|-----------|------|
| Acetaldehyde | | 75-07-0 | C ₂ H ₄ O | NR | + | 6 | + | 3.3 | + 10.23 | C25 |
| Acetic acid | Ethanoic Acid | 64-19-7 | C ₂ H ₄ O ₂ | NR | + | 22 | + | 2.6 | + 10.66 | 10 |
| Acetic anhydride | Ethanoic Acid Anhydride | 108-24-7 | C ₆ H ₈ O ₃ | NR | + | 6.1 | + | 2.0 | + 10.14 | 5 |
| Acetone | 2-Propanone | 67-64-1 | C ₃ H ₆ O | 1.2 | + | 1.1 | + | 1.4 | + 9.71 | 500 |
| Acetone cyanohydrin | 2-Hydroxyisobutyronitrile | 75-86-5 | C ₄ H ₇ NO | | | | | 4 | + 11.1 | C5 |
| Acetonitrile | Methyl cyanide, Cyanomethane | 75-05-8 | C ₂ H ₃ N | | | | | 100 | 12.19 | 40 |
| Acetylene | Ethyne | 74-86-2 | C ₂ H ₂ | | | | | 2.1 | + 11.40 | ne |
| Acrolein | Propenal | 107-02-8 | C ₃ H ₄ O | 42 | + | 3.9 | + | 1.4 | + 10.10 | 0.1 |
| Acrylic acid | Propenoic Acid | 79-10-7 | C ₃ H ₄ O ₂ | | | 12 | + | 2.0 | + 10.60 | 2 |
| Acrylonitrile | Propenenitrile | 107-13-1 | C ₃ H ₃ N | | | NR | + | 1.2 | + 10.91 | 2 |
| Allyl alcohol | | 107-18-6 | C ₃ H ₆ O | 4.5 | + | 2.4 | + | 1.6 | + 9.67 | 2 |
| Allyl chloride | | 107-05-1 | C ₃ H ₅ Cl | | | 4.3 | | 0.7 | + 9.9 | 1 |
| Ammonia | | 7664-41-7 | H ₃ N | NR | + | 9.7 | + | 5.7 | + 10.16 | 25 |
| Amyl acetate | mix of n-Pentyl acetate & 2-Methylbutyl acetate | 828-63-7 | C ₇ H ₁₄ O ₂ | 11 | + | 2.3 | + | 0.95 | + <9.9 | 100 |
| Amyl alcohol | 1-Pentanol | 75-85-4 | C ₅ H ₁₂ O | | | 5 | | 1.6 | + 10.00 | ne |
| Aniline | Aminobenzene | 62-53-3 | C ₆ H ₇ N | 0.50 | + | 0.48 | + | 0.47 | + 7.72 | 2 |
| Anisole | Methoxybenzene | 100-66-3 | C ₇ H ₈ O | 0.89 | + | 0.58 | + | 0.56 | + 8.21 | ne |
| Arsine | Arsenic trihydride | 7784-42-1 | AsH ₃ | | | 1.9 | + | | + 9.89 | 0.05 |
| Benzaldehyde | | 100-52-7 | C ₇ H ₆ O | | | | | 1 | + 9.49 | ne |
| Benzenamine, N-methyl- | N-Methylphenylamine | 100-61-8 | C ₇ H ₉ N | | | 0.7 | | | + 7.53 | |
| Benzene | | 71-43-2 | C ₆ H ₆ | 0.55 | + | 0.53 | + | 0.6 | + 9.25 | 0.5 |
| Benzonitrile | Cyanobenzene | 100-47-0 | C ₇ H ₅ N | | | 1.6 | | | + 9.62 | ne |
| Benzyl alcohol | α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol | 100-51-6 | C ₇ H ₈ O | 1.4 | + | 1.1 | + | 0.9 | + 8.26 | ne |
| Benzyl chloride | α-Chlorotoluene, Chloromethylbenzene | 100-44-7 | C ₇ H ₇ Cl | 0.7 | + | 0.6 | + | 0.5 | + 9.14 | 1 |
| Benzyl formate | Formic acid benzyl ester | 104-57-4 | C ₈ H ₈ O ₂ | 0.9 | + | 0.73 | + | 0.66 | + 7.72 | ne |
| Boron trifluoride | | 7637-07-2 | BF ₃ | NR | | NR | | NR | + 15.5 | C1 |
| Bromine | | 7726-95-6 | Br ₂ | NR | + | 1.30 | + | 0.74 | + 10.51 | 0.1 |
| Bromobenzene | | 108-88-1 | C ₆ H ₅ Br | | | 0.6 | | 0.5 | + 8.88 | ne |
| 2-Bromoethyl methyl ether | | 6482-24-2 | C ₃ H ₇ OBBr | | | 0.84 | + | | + ~10 | ne |
| Bromofom | Tribromomethane | 75-25-2 | CHBr ₃ | NR | + | 2.5 | + | 0.5 | + 10.48 | 0.5 |
| Bromopropane, 1- | n-Propyl bromide | 106-94-5 | C ₃ H ₇ Br | 150 | + | 1.5 | + | 0.6 | + 10.18 | ne |
| Butadiene | 1,3-Butadiene, Vinyl ethylene | 106-99-0 | C ₄ H ₆ | 0.8 | | 0.85 | + | 1.1 | + 9.07 | 2 |
| Butadiene diepoxide, 1,3- | 1,2,3,4-Diepoxybutane | 298-18-0 | C ₄ H ₆ O ₂ | 25 | + | 3.5 | + | 1.2 | + ~10 | ne |
| Butanal | 1-Butanal | 123-72-8 | C ₄ H ₈ O | | | 1.8 | | | + 9.84 | |
| Butane | | 106-97-8 | C ₄ H ₁₀ | | | 67 | + | 1.2 | + 10.53 | 800 |
| Butanol, 1- | Butyl alcohol, n-Butanol | 71-36-3 | C ₄ H ₁₀ O | 70 | + | 4.7 | + | 1.4 | + 9.99 | 20 |
| Butanol, t- | tert-Butanol, t-Butyl alcohol | 75-85-0 | C ₄ H ₁₀ O | 6.9 | + | 2.9 | + | | + 9.90 | 100 |
| Butene, 1- | 1-Butylene | 106-98-9 | C ₄ H ₈ | | | 0.9 | | | + 9.58 | ne |
| Butoxyethanol, 2- | Butyl Cellosolve, Ethylene glycol monobutyl ether | 111-76-2 | C ₈ H ₁₈ O ₂ | 1.8 | + | 1.2 | + | 0.6 | + <10 | 25 |
| Butoxyethanol acetate | Ethanol, 2-(2-butoxyethoxy)-, acetate | 124-17-4 | C ₁₀ H ₂₀ O ₄ | | | 5.6 | | | + ≤10.6 | |
| Butoxyethoxyethanol | 2-(2-Butoxyethoxy)ethanol | 112-34-5 | C ₈ H ₁₈ O ₃ | | | 4.6 | | | + ≤10.6 | |
| Butyl acetate, n- | | 123-86-4 | C ₈ H ₁₆ O ₂ | | | 2.6 | + | | + 10 | 150 |
| Butyl acrylate, n- | Butyl 2-propenoate, Acrylic acid butyl ester | 141-32-2 | C ₇ H ₁₂ O ₂ | | | 1.6 | + | 0.6 | + 8.71 | 10 |
| Butylamine, n- | | 109-73-9 | C ₄ H ₁₁ N | 1.1 | + | 1.1 | + | 0.7 | + 8.71 | C5 |
| Butyl cellosolve | see 2-Butoxyethanol | 111-76-2 | | | | | | | | |
| Butyl hydroperoxide, t- | | 75-91-2 | C ₈ H ₁₆ O ₂ | 2.0 | + | 1.6 | + | | + <10 | 1 |
| Butyl mercaptan | 1-Butanethiol | 109-79-5 | C ₄ H ₁₀ S | 0.55 | + | 0.52 | + | | + 8.14 | 0.5 |
| Carbon disulfide | | 75-15-0 | CS ₂ | 4 | + | 1.2 | + | 0.44 | + 10.07 | 10 |
| Carbon tetrachloride | Tetrachloromethane | 56-23-5 | CCl ₄ | NR | + | NR | + | 1.7 | + 11.47 | 5 |
| Carbonyl sulfide | Carbon oxydisulfide | 463-58-1 | COS | | | | | | + 11.18 | |
| Cellosolve see 2-Ethoxyethanol | | | | | | | | | | |
| CFC-14 see Tetrafluoromethane | | | | | | | | | | |
| CFC-113 see 1,1,2-Trichloro-1,2,2-trifluoroethane | | | | | | | | | | |
| Chlorine | | 7782-50-5 | Cl ₂ | | | | | 1.0 | + 11.48 | 0.5 |
| Chlorine dioxide | | 10048-04-4 | ClO ₂ | NR | + | NR | + | NR | + 10.57 | 0.1 |
| Chlorobenzene | Monochlorobenzene | 108-90-7 | C ₆ H ₅ Cl | 0.44 | + | 0.40 | + | 0.39 | + 9.06 | 10 |

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TABLE 1. (cont) Correction Factors and Ionization Energies



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| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (eV) | TWA | |
|--|--|----------------------|--|------|---|------|---|------|-----------|-------|-------|
| Chlorobenzotrifluoride, 4- | PCBT, OXSOL 100 p-Chlorobenzotrifluoride | 98-56-6 | C ₇ H ₄ ClF ₃ | 0.74 | + | 0.63 | + | 0.55 | + | <9.8 | 25 |
| Chloro-1,3-butadiene, 2- | Chloroprene | 126-99-8 | C ₄ H ₅ Cl | | | 3 | | | | 10 | ne |
| Chloro-1,1-difluoroethane, 1- | HCFC-142B, R-142B | 75-68-3 | C ₂ H ₂ ClF ₂ | NR | | NR | | NR | 12.0 | ne | |
| Chlorodifluoromethane | HCFC-22, R-22 | 75-45-6 | CHClF ₂ | NR | | NR | | NR | 12.2 | 1000 | |
| Chloroethane | Ethyl chloride | 75-00-3 | C ₂ H ₅ Cl | NR | + | NR | + | 1.1 | + | 10.97 | 1000 |
| Chloroethanol | Ethylene chlorohydrin | 107-07-3 | C ₂ H ₅ ClO | | | | | 2.9 | | 10.52 | C1 |
| Chloroethyl ether, 2- | bis(2-chloroethyl) ether | 111-44-4 | C ₄ H ₈ Cl ₂ O | 8.6 | + | 3.0 | + | | | | 5 |
| Chloroethyl methyl ether, 2- | Methyl 2-chloroethyl ether | 627-42-9 | C ₃ H ₇ ClO | | | 3 | | | | | ne |
| Chloroform | Trichloromethane | 67-66-3 | CHCl ₃ | NR | + | NR | + | 3.5 | + | 11.37 | 10 |
| Chloro-2-methylpropene, 3- | Methallyl chloride, Isobutenyl chloride | 563-47-3 | C ₄ H ₇ Cl | 1.4 | + | 1.2 | + | 0.83 | + | 9.78 | 10 |
| Chloropicrin | | 76-06-2 | CCl ₃ NO ₂ | NR | + | ~400 | + | 7 | + | ? | 0.1 |
| Chlorotoluene, o- | o-Chloromethylbenzene | 95-49-8 | C ₇ H ₇ Cl | | | 0.5 | | 0.6 | | 8.83 | 50 |
| Chlorotoluene, p- | p-Chloromethylbenzene | 108-43-4 | C ₇ H ₇ Cl | | | | | 0.6 | | 8.69 | ne |
| Chlorotrifluoroethene | CTFE, Chlorotrifluoroethylene Genetron 1113 | 79-38-9 | C ₂ ClF ₃ | 6.7 | + | 3.9 | + | 1.2 | + | 9.78 | 5 |
| Chlorotrimethylsilane | | 75-77-4 | C ₃ H ₉ ClSi | NR | | NR | | 0.82 | + | 10.83 | ne |
| Cresol, m- | m-Hydroxytoluene | 108-39-4 | C ₇ H ₈ O | 0.57 | + | 0.50 | + | 0.57 | + | 8.29 | 5 |
| Cresol, o- | o-Hydroxytoluene | 95-48-7 | C ₇ H ₈ O | | | 1.0 | | | | 8.60 | |
| Cresol, p- | p-Hydroxytoluene | 106-44-5 | C ₇ H ₈ O | | | 1.4 | | | | 8.35 | |
| Crotonaldehyde | trans-2-Butenal | 123-73-8 | C ₄ H ₆ O | 1.5 | + | 1.1 | + | 1.0 | + | 9.73 | 2 |
| Cumene | Isopropylbenzene | 4170-30-3 | C ₉ H ₁₂ | | | | | | | | |
| Cyanogen bromide | | 98-82-8 | C ₂ H ₂ BrN | 0.58 | + | 0.54 | + | 0.4 | + | 8.73 | 50 |
| Cyanogen chloride | | 506-68-3 | CNBr | NR | | NR | | NR | 11.84 | ne | |
| Cyclohexane | | 506-77-4 | CNCl | NR | | NR | | NR | 12.34 | C0.3 | |
| Cyclohexanol | Cyclohexyl alcohol | 110-82-7 | C ₆ H ₁₂ | 3.3 | + | 1.4 | + | 0.64 | + | 9.88 | 300 |
| Cyclohexanone | | 108-83-0 | C ₆ H ₁₀ O | 1.5 | + | 0.9 | + | 1.1 | + | 9.75 | 50 |
| Cyclohexene | | 108-94-1 | C ₆ H ₁₀ O | 1.0 | + | 0.9 | + | 0.7 | + | 9.14 | 25 |
| Cyclohexylamine | | 110-83-8 | C ₆ H ₁₀ | | | 0.8 | + | | | 8.95 | 300 |
| Cyclohexylamine | | 108-91-8 | C ₆ H ₁₃ N | | | 1.2 | | | | 8.62 | 10 |
| Cyclopentane 85% 2,2-dimethylbutane 15% | | 287-92-3 | C ₅ H ₁₀ | NR | + | 15 | + | 1.1 | | 10.33 | 600 |
| Cyclopropylamine | Aminocyclopropane | 765-30-0 | C ₃ H ₇ N | 1.1 | + | 0.9 | + | 0.9 | + | | ne |
| Decamethylcyclopentasiloxane | | 541-02-6 | C ₁₀ H ₂₀ O ₅ Si ₅ | 0.18 | + | 0.13 | + | 0.12 | + | | ne |
| Decamethyltetrasiloxane | | 141-62-8 | C ₁₀ H ₂₀ O ₃ Si ₄ | 0.17 | + | 0.13 | + | 0.12 | + | <10.2 | ne |
| Decane | | 124-18-5 | C ₁₀ H ₂₂ | 4.0 | + | 1.4 | + | 0.35 | + | 8.65 | ne |
| Diacetone alcohol | 4-Methyl-4-hydroxy-2-pentanone | 123-42-2 | C ₅ H ₁₀ O ₂ | | | 0.7 | | | | | 50 |
| Dibromochloromethane | Chlorodibromomethane | 124-48-1 | CHBr ₂ Cl | NR | + | 5.3 | + | 0.7 | + | 10.59 | ne |
| Dibromo-3-chloropropane, 1,2- | DBCP | 96-12-8 | C ₃ H ₅ Br ₂ Cl | NR | + | 1.7 | + | 0.43 | + | | 0.001 |
| Dibromoethane, 1,2- | EDB, Ethylene dibromide, Ethylene bromide | 106-93-4 | C ₂ H ₄ Br ₂ | NR | + | 1.7 | + | 0.6 | + | 10.37 | ne |
| Dichlorobenzene, o- | 1,2-Dichlorobenzene | 95-50-1 | C ₆ H ₄ Cl ₂ | 0.54 | + | 0.47 | + | 0.38 | + | 9.08 | 25 |
| Dichlorodifluoromethane | CFC-12 | 75-71-8 | CCl ₂ F ₂ | NR | + | NR | + | NR | + | 11.75 | 1000 |
| Dichlorodimethylsilane | | 75-78-5 | C ₂ H ₄ Cl ₂ Si | NR | | NR | | 1.1 | + | >10.7 | ne |
| Dichloroethane, 1,2- | EDC, 1,2-DCA, Ethylene dichloride | 107-06-2 | C ₂ H ₄ Cl ₂ | | | NR | + | 0.6 | + | 11.04 | 10 |
| Dichloroethene, 1,1- | 1,1-DCE, Vinylidene chloride | 75-35-4 | C ₂ H ₂ Cl ₂ | | | 0.82 | + | 0.8 | + | 9.79 | 5 |
| Dichloroethene, c-1,2- | c-1,2-DCE, cis-Dichloroethylene | 156-59-2 | C ₂ H ₂ Cl ₂ | | | 0.8 | | | | 9.68 | 200 |
| Dichloroethene, t-1,2- | t-1,2-DCE, trans-Dichloroethylene | 156-60-5 | C ₂ H ₂ Cl ₂ | | | 0.45 | + | 0.34 | + | 9.65 | 200 |
| Dichloro-1-fluoroethane, 1,1- | R-141B | 1717-00-6 | C ₂ H ₃ Cl ₂ F | NR | + | NR | + | 2.0 | + | | ne |
| Dichloromethane | see Methylene chloride | | | | | | | | | | |
| Dichloropentafluoropropane | AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb) | 442-56-0 507-55-1 | C ₃ HCl ₂ F ₅ | NR | + | NR | + | 25 | + | | ne |

TABLE 1. (cont) Correction Factors and Ionization Energies



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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

| Technical Note TN-106 | | | | | | | | | |
|--|--|------------------------------------|--|------|---|------|------|-------|---------------|
| Revised 12/2007 | | | | | | | | | |
| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (eV) TWA |
| Dichloropropane, 1,2- | | 78-87-5 | C ₃ H ₆ Cl ₂ | | | | 0.7 | 10.87 | 75 |
| Dichloro-1-propene, 1,3- | | 542-75-6 | C ₃ H ₄ Cl ₂ | 1.3 | + | 0.96 | + | <10 | 1 |
| Dichloro-1-propene, 2,3- | | 78-88-6 | C ₃ H ₄ Cl ₂ | 1.9 | + | 1.3 | + | 0.7 | <10 |
| Dichloro-1,1,1-trifluoroethane, 2,2- | R-123 | 306-83-2 | C ₂ HCl ₂ F ₃ | NR | + | NR | + | 10.1 | ne |
| Dichloro-2,4,6-trifluoropyridine, 3,5- | DCTFP | 1737-93-5 | C ₅ Cl ₂ F ₃ N | 1.1 | + | 0.9 | + | 0.8 | ne |
| Dichlorvos * | Vapona; O,O-dimethyl O-dichlorovinyl phosphate | 62-73-7 | C ₄ H ₇ Cl ₂ O ₄ P | | | 0.9 | + | <9.4 | 0.1 |
| Dicyclopentadiene | DCPD, Cyclopentadiene dimer | 77-73-6 | C ₁₀ H ₁₂ | 0.57 | + | 0.48 | + | 0.43 | 8.8 5 |
| Diesel Fuel | | 68334-30-5 | m.w. 228 | | | 0.9 | + | | 11 |
| Diesel Fuel #2 (Automotive) | | 68334-30-5 | m.w. 218 | 1.3 | | 0.7 | + | 0.4 | 11 |
| Diethylamine | | 109-60-7 | C ₄ H ₁₁ N | | | 1 | + | | 5 |
| Diethylaminopropylamine, 3- | | 104-78-9 | C ₇ H ₁₆ N ₂ | | | 1.3 | | | ne |
| Diethylbenzene | See Dowtherm J | | | | | | | | |
| Diethylmaleate | | 141-05-9 | C ₈ H ₁₂ O ₄ | | | 4 | | | ne |
| Diethyl sulfide | see Ethyl sulfide | | | | | | | | |
| Diglyme | See Methoxyethyl ether | 111-96-6 | C ₆ H ₁₄ O ₂ | | | | | | |
| Diisobutyl ketone | DIBK, 2,2-dimethyl-4-heptanone | 108-83-8 | C ₈ H ₁₆ O | 0.71 | + | 0.61 | + | 0.35 | 9.04 25 |
| Diisopropylamine | | 108-19-9 | C ₆ H ₁₅ N | 0.84 | + | 0.74 | + | 0.5 | 7.73 5 |
| Diketene | Ketene dimer | 674-82-8 | C ₄ H ₆ O ₂ | 2.6 | + | 2.0 | + | 1.4 | 9.6 0.5 |
| Dimethylacetamide, N,N- | DMA | 127-19-5 | C ₄ H ₉ NO | 0.87 | + | 0.8 | + | 0.8 | 8.81 10 |
| Dimethylamine | | 124-40-3 | C ₂ H ₇ N | | | 1.5 | | | 8.23 5 |
| Dimethyl carbonate | Carbonic acid dimethyl ester | 816-38-6 | C ₃ H ₆ O ₃ | NR | + | ~70 | + | 1.7 | ~10.5 ne |
| Dimethyl disulfide | DMDS | 624-92-0 | C ₂ H ₆ S ₂ | 0.2 | + | 0.20 | + | 0.21 | 7.4 ne |
| Dimethyl ether | see Methyl ether | | | | | | | | |
| Dimethylethylamine | DMEA | 598-56-1 | C ₄ H ₁₁ N | 1.1 | + | 1.0 | + | 0.9 | 7.74 ~3 |
| Dimethylformamide, N,N- | DMF | 68-12-2 | C ₃ H ₇ NO | 0.7 | + | 0.7 | + | 0.8 | 9.13 10 |
| Dimethylhydrazine, 1,1- | UDMH | 57-14-7 | C ₂ H ₈ N ₂ | | | 0.8 | + | 0.8 | 7.28 0.01 |
| Dimethyl methylphosphonate | DMMP, methyl phosphonic acid dimethyl ester | 756-79-6 | C ₃ H ₉ O ₃ P | NR | + | 4.3 | + | 0.74 | + 10.0 ne |
| Dimethyl sulfate | | 77-78-1 | C ₂ H ₆ O ₄ S | ~23 | | ~20 | + | 2.3 | + |
| Dimethyl sulfide | see Methyl sulfide | | | | | | | | |
| Dimethyl sulfoxide | DMSO, Methyl sulfoxide | 67-68-5 | C ₂ H ₆ OS | | | 1.4 | + | | 9.10 ne |
| Dioxane, 1,4- | | 123-91-1 | C ₄ H ₈ O ₂ | | | 1.3 | | | 9.19 25 |
| Dioxolane, 1,3- | Ethylene glycol formal | 646-06-0 | C ₃ H ₆ O ₂ | 4.0 | + | 2.3 | + | 1.6 | 9.9 20 |
| Dowtherm A, see Therminol® | | | | | | | | | |
| Dowtherm J (97% Diethylbenzene) * | | 25340-17-4 | C ₁₀ H ₁₄ | | | 0.5 | | | |
| DS-108F Wipe Solvent | Ethyl lactate/Isopar H/Propoxypropanol ~7:2:1 | 97-84-3 64742-48-9 1569-01-3 | m.w. 118 | 3.3 | + | 1.6 | + | 0.7 | + |
| Epichlorohydrin | ECH Chloromethyloxirane, 1-chloro-2,3-epoxypropane | 106-89-8 | C ₂ H ₅ ClO | ~200 | + | 8.5 | + | 1.4 | + |
| Ethane | | 74-84-0 | C ₂ H ₆ | | | NR | + | 15 | + |
| Ethanol | Ethyl alcohol | 64-17-5 | C ₂ H ₆ O | | | 10 | + | 3.1 | + |
| Ethanamine * | MEA, Monoethanolamine | 141-43-5 | C ₂ H ₇ NO | 5.6 | + | 1.6 | + | | 8.96 3 |
| Ethene | Ethylene | 74-85-1 | C ₂ H ₄ | | | 9 | + | 4.5 | + |
| Ethoxyethanol, 2- | Ethyl cellosolve | 110-80-5 | C ₄ H ₁₀ O ₂ | | | 1.3 | | | 8.8 5 |
| Ethyl acetate | | 141-78-6 | C ₄ H ₈ O ₂ | | | 4.6 | + | 3.5 | 10.01 400 |
| Ethyl acetoacetate | | 141-87-9 | C ₆ H ₁₀ O ₃ | 1.4 | + | 1.2 | + | 1.0 | <10 ne |
| Ethyl acrylate | | 140-88-5 | C ₅ H ₈ O ₂ | | | 2.4 | + | 1.0 | <10.3 5 |
| Ethylamine | | 75-04-7 | C ₂ H ₇ N | | | 0.8 | | | 8.88 5 |
| Ethylbenzene | | 100-41-4 | C ₈ H ₁₀ | 0.52 | + | 0.52 | + | 0.51 | + 8.77 100 |
| Ethyl caprylate | Ethyl octanoate | 106-32-1 | C ₁₀ H ₂₀ O ₂ | | | + | 0.52 | + | 0.51 |
| Ethylenediamine | 1,2-Ethanediamine; 1,2-Diaminoethane | 107-15-3 | C ₂ H ₈ N ₂ | 0.9 | + | 0.8 | + | 1.0 | + |
| Ethylene glycol * | 1,2-Ethandiol | 107-21-1 | C ₂ H ₆ O ₂ | | | 16 | + | 6 | + |
| Ethylene glycol, Acrylate | 2-hydroxyethyl Acrylate | 818-61-1 | C ₅ H ₈ O ₃ | | | 8.2 | | | ≤10.6 C100 |



TABLE 1. (cont) Correction Factors and Ionization Energies



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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

| Technical Note TN-106 | | | | | | | | | | |
|---|--|---------------------|---|------|-------|------|-----|-------|---------------|------------|
| Revised 12/2007 | | | | | | | | | | |
| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (Ev) TWA | |
| Ethylene glycol dimethyl ether | 1,2-Dimethoxyethane, Monoglyme | 110-71-4 | C ₄ H ₁₀ O ₂ | 1.1 | 0.86 | 0.7 | | 9.2 | ne | |
| Ethylene glycol monobutyl ether acetate | 2-Butoxyethyl acetate | 112-07-2 | C ₈ H ₁₆ O ₃ | | 1.3 | | | ≤10.6 | | |
| Ethylene glycol, monothio | mercapto-2-ethanol | 60-24-2 | C ₂ H ₆ OS | | 1.5 | | | 9.65 | 1 | |
| Ethylene oxide | Oxirane, Epoxymethane | 75-21-8 | C ₂ H ₄ O | | 13 | + | 3.5 | + | 10.57 | |
| Ethyl ether | Diethyl ether | 60-29-7 | C ₄ H ₁₀ O | | 1.1 | + | 1.7 | | 9.51 400 | |
| Ethyl 3-ethoxypropionate | EEP | 763-89-9 | C ₇ H ₁₄ O ₃ | 1.2 | + | 0.75 | + | | ne | |
| Ethyl formate | | 106-84-4 | C ₃ H ₆ O ₂ | | | 1.9 | | 10.61 | 100 | |
| Ethylhexyl acrylate, 2- | Acrylic acid 2-ethylhexyl ester | 103-11-7 | C ₁₁ H ₂₀ O ₂ | | 1.1 | + | 0.5 | + | ne | |
| Ethylhexanol | 2-Ethyl-1-hexanol | 104-76-7 | C ₈ H ₁₈ O | | 1.9 | | | ≤10.6 | | |
| Ethylidenenorbornene | 5-Ethylidene bicyclo(2,2,1)hept-2-ene | 16219-75-3 | C ₉ H ₁₂ | 0.4 | + | 0.39 | + | 0.34 | + | ≤8.8 ne |
| Ethyl (S)-(-)-lactate see also DS-108F | Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate | 867-47-8 97-64-3 | C ₅ H ₁₀ O ₃ | 13 | + | 3.2 | + | 1.6 | + | ~10 ne |
| Ethyl mercaptan | Ethanethiol | 75-08-1 | C ₂ H ₆ S | 0.80 | + | 0.56 | + | | | 9.29 0.5 |
| Ethyl sulfide | Diethyl sulfide | 352-93-2 | C ₄ H ₁₀ S | | 0.5 | + | | | | 8.43 ne |
| Formaldehyde | Formalin | 50-00-0 | CH ₂ O | NR | + | NR | + | 1.6 | + | 10.87 C0.3 |
| Formamide | | 75-12-7 | CH ₃ NO | | 6.9 | + | 4 | | | 10.16 10 |
| Formic acid | | 64-18-6 | CH ₂ O ₂ | NR | + | NR | + | 9 | + | 11.33 5 |
| Furfural | 2-Furaldehyde | 98-01-1 | C ₅ H ₄ O ₂ | | 0.92 | + | 0.8 | + | | 9.21 2 |
| Furfuryl alcohol | | 98-00-0 | C ₅ H ₆ O ₂ | | 0.80 | + | | | | <9.5 10 |
| Gasoline #1 | | 8008-61-9 | m.w. 72 | | 0.9 | + | | | | 300 |
| Gasoline #2, 92 octane | | 8008-61-9 | m.w. 93 | 1.3 | + | 1.0 | + | 0.5 | + | 300 |
| Glutaraldehyde | 1,5-Pentanedial, Glutaric dialdehyde | 111-30-8 | C ₅ H ₈ O ₂ | 1.1 | + | 0.8 | + | 0.8 | + | C0.05 |
| Glycidyl methacrylate | 2,3-Epoxypropyl methacrylate | 106-81-2 | C ₇ H ₁₀ O ₃ | 2.6 | + | 1.2 | + | 0.9 | + | 0.5 |
| Halothane | 2-Bromo-2-chloro-1,1,1-trifluoroethane | 151-67-7 | C ₂ HBrClF ₃ | | | | | 0.6 | | 11.0 50 |
| HCFC-22 see Chlorodifluoromethane | | | | | | | | | | |
| HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane | | | | | | | | | | |
| HCFC-141B see 1,1-Dichloro-1-fluoroethane | | | | | | | | | | |
| HCFC-142B see 1-Chloro-1,1-difluoroethane | | | | | | | | | | |
| HCFC-134A see 1,1,1,2-Tetrafluoroethane | | | | | | | | | | |
| HCFC-225 see Dichloropentafluoropropane | | | | | | | | | | |
| Heptane, n- | | 142-82-5 | C ₇ H ₁₆ | 45 | + | 2.8 | + | 0.60 | + | 9.92 400 |
| Heptanol, 4- | Dipropylcarbinol | 589-55-9 | C ₇ H ₁₆ O | 1.8 | + | 1.3 | + | 0.5 | + | 9.61 ne |
| Hexamethyldisilazane, 1,1,1,3,3,3-* | HMDS | 969-97-3 | C ₆ H ₁₅ NSi ₂ | | 0.2 | + | 0.2 | + | | ~8.6 ne |
| Hexamethyldisiloxane | HMDSx | 107-46-0 | C ₆ H ₁₆ OSi ₂ | 0.33 | + | 0.27 | + | 0.25 | + | 9.64 ne |
| Hexane, n- | | 110-54-3 | C ₆ H ₁₄ | 350 | + | 4.3 | + | 0.54 | + | 10.13 50 |
| Hexanol, 1- | Hexyl alcohol | 111-27-3 | C ₆ H ₁₄ O | 9 | + | 2.5 | + | 0.55 | + | 9.89 ne |
| Hexene, 1- | | 582-41-6 | C ₆ H ₁₂ | | 0.8 | | | | | 9.44 30 |
| HFE-7100 | see Methyl nonafluorobutyl ether | | | | | | | | | |
| Histoclear (Histo-Clear) | Limonene/corn oil reagent | | m.w. ~138 | 0.5 | + | 0.4 | + | 0.3 | + | ne |
| Hydrazine * | | 302-01-2 | H ₂ N ₂ | >8 | + | 2.6 | + | 2.1 | + | 8.1 0.01 |
| Hydrazoic acid | Hydrogen azide | | HN ₃ | | | | | | | 10.7 |
| Hydrogen | Synthesis gas | 1333-74-0 | H ₂ | NR | + | NR | + | NR | + | 15.43 ne |
| Hydrogen cyanide | Hydrocyanic acid | 74-90-8 | HCN | NR | + | NR | + | NR | + | 13.6 C4.7 |
| Hydrogen iodide * | Hydriodic acid | 10034-85-2 | HI | | ~0.6* | | | | | 10.39 |
| Hydrogen peroxide | | 7722-84-1 | H ₂ O ₂ | NR | + | NR | + | NR | + | 10.54 1 |
| Hydrogen sulfide | | 7783-08-4 | H ₂ S | NR | + | 3.3 | + | 1.5 | + | 10.45 10 |
| Hydroxypropyl methacrylate | | 27813-02-1 | C ₇ H ₁₂ O ₃ | 8.9 | + | 2.3 | + | 1.1 | + | ne |
| Iodine * | | 7553-56-2 | I ₂ | 0.1 | + | 0.1 | + | 0.1 | + | 9.40 C0.1 |
| Iodomethane | Methyl iodide | 74-88-4 | CH ₃ I | 0.21 | + | 0.22 | + | 0.26 | + | 9.54 2 |
| Isoamyl acetate | Isopentyl acetate | 123-92-2 | C ₇ H ₁₄ O ₂ | 10.1 | | 2.1 | | 1.0 | | <10 100 |
| Isobutane | 2-Methylpropane | 75-28-5 | C ₄ H ₁₀ | | 100 | + | 1.2 | + | | 10.57 ne |
| Isobutanol | 2-Methyl-1-propanol | 78-83-1 | C ₄ H ₁₀ O | 19 | + | 3.8 | + | 1.5 | + | 10.02 50 |
| Isobutene | Isobutylene, Methyl butene | 115-11-7 | C ₄ H ₈ | 1.00 | + | 1.00 | + | 1.00 | + | 9.24 Ne |



TABLE 1. (cont) Correction Factors and Ionization Energies



STANDARD OPERATING PROCEDURES

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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS



Technical Note TN-106

Revised 12/2007

| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (eV) | TWA |
|---|--|--|----------------------------|------|---|------|---|------|-----------|------------------------------------|
| Isobutyl acrylate | Isobutyl 2-propenoate | 106-63-8 | $C_{11}H_{18}O_2$ | | | 1.5 | + | 0.60 | + | Ne |
| Isoflurane | 1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane | 26675-46-7 | $C_2H_2ClF_5O$ | NR | + | NR | + | 48 | + | ~11.7 Ne |
| Isooctane | 2,2,4-Trimethylpentane | 540-84-1 | C_8H_{18} | | | 1.2 | | | | 9.86 ne |
| Isopar E Solvent | Isoparaffinic hydrocarbons | 64741-66-8 | m.w. 121 | 1.7 | + | 0.8 | + | | | Ne |
| Isopar G Solvent | Photocopier diluent | 64742-48-9 | m.w. 148 | | | 0.8 | + | | | Ne |
| Isopar K Solvent | Isoparaffinic hydrocarbons | 64742-48-9 | m.w. 158 | 0.9 | + | 0.5 | + | 0.27 | + | Ne |
| Isopar L Solvent | Isoparaffinic hydrocarbons | 64742-48-9 | m.w. 163 | 0.9 | + | 0.5 | + | 0.28 | + | Ne |
| Isopar M Solvent | Isoparaffinic hydrocarbons | 64742-47-8 | m.w. 191 | | | 0.7 | + | 0.4 | + | Ne |
| Isoptane | 2-Methylbutane | 78-78-4 | C_5H_{12} | | | 8.2 | | | | Ne |
| Isophorone | | 78-58-1 | $C_{10}H_{18}O$ | | | 3 | | | | 9.07 C5 |
| Isoprene | 2-Methyl-1,3-butadiene | 78-78-5 | C_5H_8 | 0.69 | + | 0.63 | + | 0.60 | + | 8.85 Ne |
| Isopropanol | Isopropyl alcohol, 2-propanol, IPA | 67-63-0 | C_3H_8O | 500 | + | 6.0 | + | 2.7 | | 10.12 200 |
| Isopropyl acetate | | 108-21-4 | $C_7H_{14}O_2$ | | | 2.6 | | | | 9.96 100 |
| Isopropyl ether | Diisopropyl ether | 108-20-3 | $C_6H_{14}O$ | | | 0.8 | | | | 9.20 250 |
| Jet fuel JP-4 | Jet B, Turbo B, F-40 Wide cut type aviation fuel | 8008-20-6 + 64741-42-0 | m.w. 115 | 1.0 | + | 0.4 | + | | | Ne |
| Jet fuel JP-5 | Jet 5, F-44, Kerosene type aviation fuel | 8008-20-6 + 64747-77-1 | m.w. 167 | | | 0.6 | + | 0.5 | + | 29 |
| Jet fuel JP-8 | Jet A-1, F-34, Kerosene type aviation fuel | 8008-20-6 + 64741-77-1 | m.w. 165 | | | 0.8 | + | 0.3 | + | 30 |
| Jet fuel A-1 (JP-8) | F-34, Kerosene type aviation fuel | 8008-20-6 + 64741-77-1 | m.w. 145 | | | 0.67 | | | | 34 |
| Jet Fuel TS | Thermally Stable Jet Fuel, Hydrotreated kerosene fuel (R)-(+)-Limonene | 8008-20-6 + 64742-47-8 5889-27-5 | m.w. 165 $C_{10}H_{16}$ | 0.9 | + | 0.6 | + | 0.3 | + | 30 |
| Limonene, D- | | 8008-20-6 | | | | 0.33 | + | | | ~8.2 Ne |
| Kerosene C10-C16 petro. distillate | — see Jet Fuels | | | | | | | | | |
| MDI — see 4,4'-Methylenebis(phenylisocyanate) | | | | | | | | | | |
| Maleic anhydride | 2,5-Furandione | 108-31-6 | $C_4H_2O_3$ | | | | | | | ~10.8 0.1 |
| Mesitylene | 1,3,5-Trimethylbenzene | 108-67-8 | C_9H_{12} | 0.36 | + | 0.35 | + | 0.3 | + | 8.41 25 |
| Methallyl chloride — see 3-Chloro-2-methylpropene | | | | | | | | | | |
| Methane | Natural gas | 74-82-8 | CH_4 | NR | + | NR | + | NR | + | 12.61 Ne |
| Methanol | Methyl alcohol, carbinol | 67-56-1 | CH_4O | NR | + | NR | + | 2.5 | + | 10.85 200 |
| Methoxyethanol, 2- | Methyl cellosolve, Ethylene glycol monomethyl ether | 109-86-4 | $C_3H_8O_2$ | 4.8 | + | 2.4 | + | 1.4 | + | 10.1 5 |
| Methoxyethoxyethanol, 2- | 2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether | 111-77-3 | $C_7H_{16}O$ | 2.3 | + | 1.2 | + | 0.9 | + | <10 Ne |
| Methoxyethyl ether, 2- | bis(2-Methoxyethyl) ether, Diethylene glycol dimethyl ether, Diglyme | 111-96-6 | $C_6H_{14}O_2$ | 0.64 | + | 0.54 | + | 0.44 | + | <9.8 Ne |
| Methyl acetate | | 79-20-9 | $C_4H_8O_2$ | NR | + | 6.8 | + | 1.4 | + | 10.27 200 |
| Methyl acrylate | Methyl 2-propenoate, Acrylic acid methyl ester | 96-33-3 | $C_5H_8O_2$ | | | 3.7 | + | 1.2 | + | (9.9) 2 |
| Methylamine | Aminomethane | 74-89-5 | CH_5N | | | 1.2 | | | | 8.97 5 |
| Methyl amyl ketone | MAK, 2-Heptanone, Methyl pentyl ketone | 110-43-0 | $C_7H_{14}O$ | 0.9 | + | 0.85 | + | 0.5 | + | 9.30 50 |
| Methyl bromide | Bromomethane | 74-83-0 | CH_3Br | 110 | + | 1.7 | + | 1.3 | + | 10.54 1 |
| Methyl t-butyl ether | MTBE, tert-Butyl methyl ether | 1634-04-4 | $C_5H_{12}O$ | | | 0.9 | + | | | 9.24 40 |
| Methyl cellosolve | see 2-Methoxyethanol | | | | | | | | | |
| Methyl chloride | Chloromethane | 74-87-3 | CH_3Cl | NR | + | NR | + | 0.74 | + | 11.22 50 |
| Methyldichlorobenzene | | 107-87-2 | $C_7H_4Cl_2$ | 1.6 | + | 0.97 | + | 0.63 | + | 9.64 400 |
| Methylene bis(phenylisocyanate), 4,4'- | MDI, Mondur M | | $C_{15}H_{10}N_2O_2$ | | | | | | | Very slow ppb level response 0.005 |
| Methylene chloride | Dichloromethane | 75-09-2 | CH_2Cl_2 | NR | + | NR | + | 0.89 | + | 11.32 25 |
| Methyl ether | Dimethyl ether | 115-10-6 | C_2H_6O | 4.8 | + | 3.1 | + | 2.5 | + | 10.03 Ne |
| Methyl ethyl ketone | MEK, 2-Butanone | 78-93-3 | C_4H_8O | 0.88 | + | 0.9 | + | 1.1 | + | 9.51 200 |
| Methylhydrazine | Monomethylhydrazine, Hydrazomethane | 60-34-4 | $C_2H_6N_2$ | 1.4 | + | 1.2 | + | 1.3 | + | 7.7 0.01 |
| Methyl isomyl ketone | MIAK, 5-Methyl-2-hexanone | 110-12-3 | $C_7H_{14}O$ | 0.8 | + | 0.76 | + | 0.5 | + | 9.28 50 |

TABLE



4

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1. (cont)

Correction Factors and Ionization Energies



STANDARD OPERATING PROCEDURES

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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

| | | | | Technical Note TN-106 | | | | | |
|---|---|----------------------------------|---|-----------------------|-------|-------|--------|------|------------|
| | | | | Revised 12/2007 | | | | | |
| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 0.9 | + 0.8 | + 0.6 | + 0.30 | 50 | |
| Methyl isobutyl ketone | MIBK, 4-Methyl-2-pentanone | 108-10-1 | C ₈ H ₁₆ O | NR | + | 4.6 | + | 1.5 | 10.67 0.02 |
| Methyl isocyanate | CH ₃ NCO | 624-83-8 | C ₂ H ₃ NO | NR | + | 0.45 | + | 0.4 | 9.25 ne |
| Methyl isothiocyanate | CH ₃ NCS | 551-81-6 | C ₂ H ₃ NS | 0.65 | + | 0.54 | + | 0.66 | 9.44 0.5 |
| Methyl mercaptan | Methanethiol | 74-93-1 | CH ₄ S | 2.7 | + | 1.5 | + | 1.2 | 9.7 100 |
| Methyl methacrylate | | 80-62-6 | C ₅ H ₈ O ₂ | NR | + | ~35 | + | | ne |
| Methyl nonafluorobutyl ether | HFE-7100DL | 163702-08-7, 163702-07-6 | C ₅ H ₉ F ₉ O | | | | | | |
| Methyl-1,5-pentanediamine, 2- (coats lamp) * | Dytek-A amine, 2-Methyl pentamethylenediamine | 15620-10-2 | C ₈ H ₁₈ N ₂ | ~0.6 | + | | | <9.0 | ne |
| Methyl propyl ketone | MPK, 2-Pentanone | 107-87-9 | C ₇ H ₁₄ O | | | 0.93 | + | 0.79 | 9.38 200 |
| Methyl-2-pyrrolidinone, N- | NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone | 872-50-4 | C ₅ H ₉ NO | 1.0 | + | 0.8 | + | 0.9 | 9.17 ne |
| Methyl salicylate | Methyl 2-hydroxybenzoate | 119-36-8 | C ₉ H ₈ O ₃ | 1.3 | + | 0.9 | + | 0.9 | ~9 ne |
| Methylstyrene, α- | 2-Propenylbenzene | 98-83-9 | C ₉ H ₁₀ | | | 0.5 | | | 8.18 50 |
| Methyl sulfide | DMS, Dimethyl sulfide | 75-18-3 | C ₂ H ₆ S | 0.49 | + | 0.44 | + | 0.46 | 8.69 ne |
| Mineral spirits | Stoddard Solvent, Varsol 1, White Spirits | 8020-83-5, 8052-41-3, 88551-17-7 | m.w. 144 | 1.0 | + | 0.69 | + | 0.38 | 100 |
| Mineral Spirits - Viscor 1208 Calibration Fluid, b.p. 156-207°C | | 8052-41-3 | m.w. 142 | 1.0 | + | 0.7 | + | 0.3 | 100 |
| Monethanolamine - see Ethanolamine | | | | | | | | | |
| Mustard * | HD, Bis(2-chloroethyl) sulfide | 505-80-2, 38472-40-7, 88157-62-0 | C ₄ H ₈ Cl ₂ S | | | 0.8 | | | 0.0005 |
| Naphtha - see VM & P Naptha | | | | | | | | | |
| Naphthalene | Mothballs | 91-20-3 | C ₁₀ H ₈ | 0.45 | + | 0.42 | + | 0.40 | 8.13 10 |
| Nickel carbonyl (in CO) | Nickel tetracarbonyl | 13463-30-3 | C ₄ NiO ₄ | | | 0.18 | | | <8.8 0.001 |
| Nicotine | | 54-11-5 | C ₁₀ H ₁₄ N ₂ | | | 2.0 | | | ≤10.6 |
| Nitric oxide | | 10102-43-9 | NO | ~6 | | 5.2 | + | 2.8 | 9.26 25 |
| Nitrobenzene | | 98-95-3 | C ₆ H ₅ NO ₂ | 2.6 | + | 1.9 | + | 1.6 | 8.81 1 |
| Nitroethane | | 79-24-3 | C ₂ H ₅ NO ₂ | | | | | 3 | 10.88 100 |
| Nitrogen dioxide | | 10102-44-0 | NO ₂ | 23 | + | 16 | + | 6 | 9.75 3 |
| Nitrogen trifluoride | | 7783-54-2 | NF ₃ | NR | | NR | | NR | 13.0 10 |
| Nitromethane | | 75-52-5 | CH ₃ NO ₂ | | | | | 4 | 11.02 20 |
| Nitropropane, 2- | | 79-46-9 | C ₃ H ₇ NO ₂ | | | | | 2.6 | 10.71 10 |
| Nonane | | 111-84-2 | C ₉ H ₂₀ | | | 1.4 | | | 9.72 200 |
| Norpar 12 | n-Paraffins, mostly C ₁₀ -C ₁₃ | 84771-72-8 | m.w. 161 | 3.2 | + | 1.1 | + | 0.28 | ne |
| Norpar 13 | n-Paraffins, mostly C ₁₃ -C ₁₄ | 84771-72-8 | m.w. 189 | 2.7 | + | 1.0 | + | 0.3 | ne |
| Octamethylcyclotetrasiloxane | | 556-87-2 | C ₈ H ₂₄ O ₄ Si ₄ | 0.21 | + | 0.17 | + | 0.14 | ne |
| Octamethyltrisiloxane | | 107-51-7 | C ₈ H ₂₄ O ₃ Si ₃ | 0.23 | + | 0.18 | + | 0.17 | <10.0 ne |
| Octane, n- | | 111-85-9 | C ₈ H ₁₈ | 13 | + | 1.8 | + | | 9.82 300 |
| Octene, 1- | | 111-86-0 | C ₈ H ₁₆ | 0.9 | + | 0.75 | + | 0.4 | 9.43 75 |
| Pentane | | 109-66-0 | C ₅ H ₁₂ | 80 | + | 8.4 | + | 0.7 | 10.35 800 |
| Peroacetic acid * | Peroxyacetic acid, Acetyl hydroperoxide | 79-21-0 | C ₂ H ₄ O ₃ | NR | + | NR | + | 2.3 | ne |
| Peroacetic/Acetic acid mix * | Peroxyacetic acid, Acetyl hydroperoxide | 79-21-0 | C ₂ H ₄ O ₃ | | | 50 | + | 2.5 | ne |
| Perchloroethene | PCE, Perchloroethylene, Tetrachloroethylene | 127-18-4 | C ₂ Cl ₄ | 0.69 | + | 0.57 | + | 0.31 | 9.32 25 |
| PGME | Propylene glycol methyl ether, 1-Methoxy-2-propanol | 107-88-2 | C ₄ H ₁₀ O ₂ | 2.4 | + | 1.5 | + | 1.1 | 100 |
| PGMEA | Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate | 108-65-6 | C ₆ H ₁₂ O ₃ | 1.65 | + | 1.0 | + | 0.8 | ne |
| Phenol | Hydroxybenzene | 108-95-2 | C ₆ H ₆ O | 1.0 | + | 1.0 | + | 0.9 | 8.51 5 |
| Phosgene | Dichlorocarbonyl | 75-44-5 | CCl ₂ O | NR | + | NR | + | 8.5 | 11.2 0.1 |
| Phosgene in Nitrogen | Dichlorocarbonyl | 75-44-5 | CCl ₂ O | NR | + | NR | + | 6.8 | 11.2 0.1 |
| Phosphine (coats lamp) | | 7803-51-2 | PH ₃ | 28 | + | 3.9 | + | 1.1 | 9.87 0.3 |



TABLE 1. (cont) Correction Factors and Ionization Energies



STANDARD OPERATING PROCEDURES

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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS

Technical Note TN-106

Revised 12/2007

| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (eV) | TWA |
|--|--|------------|---|------|---|------|---|------|-----------|-------|
| Photocopier Toner | Isoparaffin mix | | | | | 0.5 | + | 0.3 | + | ne |
| Picoline, 3- | 3-Methylpyridine | 108-99-6 | C ₆ H ₇ N | | | 0.9 | | | 9.04 | ne |
| Pinene, α- | | 2437-85-8 | C ₁₀ H ₁₆ | | | 0.31 | + | 0.47 | 8.07 | ne |
| Pinene, β- | | 18172-87-3 | C ₁₀ H ₁₆ | 0.38 | + | 0.37 | + | 0.37 | ~8 | 100 |
| Piperylene, isomer mix | 1,3-Pentadiene | 504-60-9 | C ₅ H ₆ | 0.76 | + | 0.69 | + | 0.64 | 8.8 | 100 |
| Propane | | 74-98-6 | C ₃ H ₈ | | | NR | + | 1.8 | 10.95 | 2500 |
| Propanol, n- | Propyl alcohol | 71-23-8 | C ₃ H ₇ O | | | 5 | | 1.7 | 10.22 | 200 |
| Propene | Propylene | 115-07-1 | C ₃ H ₆ | 1.5 | + | 1.4 | + | 1.6 | 9.73 | ne |
| Propionaldehyde | Propanal | 123-38-6 | C ₃ H ₆ O | | | 1.8 | | | 9.86 | ne |
| Propyl acetate, n- | | 109-80-4 | C ₅ H ₁₀ O ₂ | | | 3.5 | | 2.3 | 10.04 | 200 |
| Propylamine, n- | 1-Propylamine, 1-Aminopropane | 107-10-8 | C ₃ H ₇ N | 1.1 | + | 1.1 | + | 0.9 | 8.78 | ne |
| Propylene carbonate * | | 108-32-7 | C ₄ H ₆ O ₃ | | | 82 | + | 1 | 10.5 | ne |
| Propylene glycol | 1,2-Propanediol | 57-58-6 | C ₃ H ₈ O ₂ | 18 | | 5.5 | + | 1.6 | <10.2 | ne |
| Propylene glycol propyl ether | 1-Propoxy-2-propanol | 1569-01-3 | C ₆ H ₁₄ O ₂ | 1.3 | + | 1.0 | + | 1.6 | + | ne |
| Propylene oxide | Methyloxirane | 75-56-9 | C ₃ H ₆ O | ~240 | | 6.6 | + | 2.9 | 10.22 | 20 |
| | | 16088-62-3 | | | | | | | | |
| | | 15448-47-2 | | | | | | | | |
| Propyleneimine | 2-Methylaziridine | 75-55-8 | C ₃ H ₅ N | 1.5 | + | 1.3 | + | 1.0 | 9.0 | 2 |
| Propyl mercaptan, 2- | 2-Propanethiol, Isopropyl mercaptan | 75-33-2 | C ₃ H ₇ S | 0.64 | + | 0.66 | + | | 9.15 | ne |
| Pyridine | | 110-86-1 | C ₅ H ₅ N | 0.78 | + | 0.7 | + | 0.7 | 9.25 | 5 |
| Pyrrolidine (coats lamp) | Azacyclohexane | 123-75-1 | C ₄ H ₇ N | 2.1 | + | 1.3 | + | 1.6 | ~8.0 | ne |
| RR7300 (PGME/PGMEA) | 70:30 PGME:PGMEA (1-Methoxy-2-propanol:1-Methoxy-2-acetoxypropane) | 107-88-2 | C ₆ H ₁₂ O ₃ / C ₆ H ₁₂ O ₃ | | | 1.4 | + | 1.0 | + | ne |
| Sarin | GB, Isopropyl methylphosphonofluoridate | 107-44-8 | C ₄ H ₁₀ FO ₂ P | | | ~3 | | | | |
| Stoddard Solvent - see Mineral Spirits | | 50642-23-4 | | | | | | | | |
| Styrene | | 8020-83-6 | C ₈ H ₈ | 0.45 | + | 0.40 | + | 0.4 | 8.43 | 20 |
| Sulfur dioxide | | 100-42-5 | SO ₂ | NR | | NR | + | NR | 12.32 | 2 |
| Sulfur hexafluoride | | 7446-09-5 | SF ₆ | NR | | NR | | NR | 15.3 | 1000 |
| Sulfuryl fluoride | Vikane | 2551-82-4 | SO ₂ F ₂ | NR | | NR | | NR | 13.0 | 5 |
| Tabun * | Ethyl N, N-dimethylphosphoramidocyanidate | 2689-79-8 | C ₅ H ₁₁ N ₂ O ₂ P | | | 0.8 | | | 15ppt | |
| | | 77-81-5 | | | | | | | | |
| Tetrachloroethane, 1,1,1,2- | | 630-20-6 | C ₂ HCl ₃ | | | | | 1.3 | ~11.1 | ne |
| Tetrachloroethane, 1,1,2,2- | | 79-34-5 | C ₂ H ₂ Cl ₄ | NR | + | NR | + | 0.80 | ~11.1 | 1 |
| Tetraethoxysilane | TEL | 10023-04-7 | SiCl ₄ | NR | | NR | | 16 | 11.79 | ne |
| Tetraethyl lead | | 78-00-2 | C ₈ H ₁₆ Pb | 0.4 | | 0.3 | | 0.2 | ~11.1 | 0.008 |
| Tetraethyl orthosilicate | Ethyl silicate, TEOS | 78-10-4 | C ₄ H ₁₀ O ₄ Si | | | 0.7 | + | 0.2 | ~8.8 | 10 |
| Tetrafluoroethane, 1,1,1,2- | HFC-134A | 811-87-2 | C ₂ H ₂ F ₄ | NR | | NR | | NR | | ne |
| Tetrafluoroethene | TFE, Tetrafluoroethylene, Perfluoroethylene | 116-14-3 | C ₂ F ₄ | | | ~15 | | | 10.12 | ne |
| Tetrafluoromethane | CFC-14, Carbon tetrafluoride | 75-73-0 | CF ₄ | | | NR | + | NR | >15.3 | ne |
| Tetrahydrofuran | THF | 108-99-9 | C ₄ H ₈ O | 1.9 | + | 1.7 | + | 1.0 | 9.41 | 200 |
| Tetramethyl orthosilicate | Methyl silicate, TMOS | 681-84-5 | C ₄ H ₁₂ O ₄ Si | 10 | + | 1.8 | + | | ~10 | 1 |
| Therminol® D-12 * | Hydrotreated heavy naphtha | 84742-48-9 | m.w. 160 | 0.8 | + | 0.51 | + | 0.33 | + | ne |
| Therminol® VP-1 * | Dowtherm A, 3:1 Diphenyl oxide | 101-84-8 | C ₁₂ H ₁₀ O | | | 0.4 | + | | | 1 |
| | Biphenyl | 92-52-4 | C ₁₂ H ₁₀ | | | | | | | |
| Toluene | Methylbenzene | 108-88-3 | C ₇ H ₈ | 0.54 | + | 0.50 | + | 0.51 | 8.82 | 50 |
| Tolyene-2,4-diisocyanate | TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate | 584-84-9 | C ₉ H ₆ N ₂ O ₂ | 1.4 | + | 1.4 | + | 2.0 | 0.002 | |
| Trichlorobenzene, 1,2,4- | 1,2,4-TCB | 120-82-1 | C ₆ H ₃ Cl ₃ | 0.7 | + | 0.46 | + | | 9.04 | C5 |
| Trichloroethane, 1,1,1- | 1,1,1-TCA, Methyl chloroform | 71-55-6 | C ₂ H ₃ Cl ₃ | NR | + | NR | + | 1 | 11 | 350 |
| Trichloroethane, 1,1,2- | 1,1,2-TCA | 79-00-5 | C ₂ H ₃ Cl ₃ | NR | + | NR | + | 0.9 | 11.0 | 10 |
| Trichloroethene | TCE, Trichloroethylene | 79-01-6 | C ₂ HCl ₃ | 0.62 | + | 0.54 | + | 0.43 | 9.47 | 50 |
| Trichloromethylsilane | Methyltrichlorosilane | 75-79-6 | CH ₃ Cl ₃ Si | NR | | NR | | 1.8 | 11.36 | ne |
| Trichlorotrifluoroethane, 1,1,2- | CFC-113 | 76-13-1 | C ₂ Cl ₃ F ₃ | NR | | NR | | NR | 11.89 | 1000 |
| Triethylamine | TEA | 121-44-8 | C ₆ H ₁₅ N | 0.95 | + | 0.9 | + | 0.85 | 7.3 | 1 |
| Triethyl borate | TEB; Boric acid triethyl ester | 150-46-9 | C ₆ H ₁₅ O ₃ B | | | 2.2 | + | 1.1 | ~10 | ne |



TABLE 1. (cont) Correction Factors and Ionization Energies



STANDARD OPERATING PROCEDURES

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MULTI GAS MONITOR PGM-50/PHOTOIONIZATION DETECTOR (PID) MULTIRAE PLUS



Technical Note TN-106

Revised 12/2007

| Compound Name | Synonym/Abbreviation | CAS No. | Formula | 9.8 | C | 10.6 | C | 11.7 | C IE (eV) | TWA |
|--|---|------------|---------------------------|------|---|------|---|------|-----------|----------|
| Triethyl phosphate | Ethyl phosphate | 78-40-0 | $C_6H_{15}O_4P$ | ~50 | + | 3.1 | + | 0.80 | + | 9.79 ne |
| Trifluoroethane, 1,1,2- | | 430-86-0 | $C_2H_2F_3$ | | | | | 34 | | 12.9 ne |
| Trimethylamine | | 75-50-3 | C_3H_9N | | | 0.0 | | | | 7.82 5 |
| Trimethylbenzene, 1,3,5- - see Mesitylene | | 108-67-8 | | | | | | | | 25 |
| Trimethyl borate | TMB: Boric acid trimethyl ester, Boron methoxide | 121-43-7 | $C_3H_9O_3B$ | | | 5.1 | + | 1.2 | + | 10.1 ne |
| Trimethyl phosphate | Methyl phosphate | 512-58-1 | $C_3H_9O_4P$ | | | 8.0 | + | 1.3 | + | 9.99 ne |
| Trimethyl phosphite | Methyl phosphite | 121-45-0 | $C_3H_9O_3P$ | | | 1.1 | + | | + | 8.5 2 |
| Turpentine | Pinenes (85%) + other diisoprenes | 8008-64-2 | $C_{10}H_{16}$ | 0.37 | + | 0.30 | + | 0.28 | + | ~8 20 |
| Undecane | | 1120-21-4 | $C_{11}H_{24}$ | | | 2 | | | | 9.56 ne |
| Varsol - see Mineral Spirits | | | | | | | | | | |
| Vinyl acetate | | 108-05-4 | $C_4H_6O_2$ | 1.5 | + | 1.2 | + | 1.0 | + | 9.19 10 |
| Vinyl bromide | Bromoethylene | 583-80-2 | C_2H_3Br | | | 0.4 | | | | 9.80 5 |
| Vinyl chloride | Chloroethylene, VCM | 75-01-4 | C_2H_3Cl | | | 2.0 | + | 0.6 | + | 9.99 5 |
| Vinyl-1-cyclohexene, 4- | Butadiene dimer, 4-Ethenylcyclohexene | 100-40-3 | C_8H_{12} | 0.6 | + | 0.56 | + | | | 9.83 0.1 |
| Vinylidene chloride - see 1,1-Dichloroethene | | | | | | | | | | |
| Vinyl-2-pyrrolidinone, 1- | NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone | 88-12-0 | C_6H_9NO | 1.0 | + | 0.8 | + | 0.9 | + | ne |
| Viscor 120B - see Mineral Spirits | Viscor 120B Calibration Fluid | | | | | | | | | |
| V. M. & P. Naphtha | Ligroin; Solvent naphtha; Varnish maker's & painter's naphtha | 84742-80-8 | m.w. 111 (C_8-C_{10}) | 1.7 | + | 0.97 | + | | | 300 |
| Xylene, m- | 1,3-Dimethylbenzene | 108-38-3 | C_8H_{10} | 0.50 | + | 0.44 | + | 0.40 | + | 8.56 100 |
| Xylene, o- | 1,2-Dimethylbenzene | 95-47-6 | C_8H_{10} | 0.56 | + | 0.46 | + | 0.43 | | 8.56 100 |
| Xylene, p- | 1,4-Dimethylbenzene | 106-42-3 | C_8H_{10} | 0.48 | + | 0.39 | + | 0.38 | + | 8.44 100 |
| None | | | | 1 | | 1 | | 1 | | |
| Undetectable | | | | 1E+6 | | 1E+6 | | 1E+6 | | |

* Compounds indicated in green can be detected using a MiniRAE 2000 or ppbRAE+ with slow response, but may be lost by adsorption on a MultiRAE or EntryRAE. Response on multi-gas meters can give an indication of relative concentrations, but may not be quantitative and for some chemicals no response is observed.

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Appendix I:

Example of Automatic Calculation of Correction Factors, TLVs and Alarm Limits for Mixtures
(Calculations performed using Excel version of this database, available on request)

| Compound | CF 9.8 eV | CF 10.6 eV | CF 11.7 eV | Mol. Frac | Conc ppm | TLV ppm | STEL Ppm |
|---|--------------|---------------|---------------|--------------|-------------|------------|-------------|
| Benzene | 0.55 | 0.53 | 0.6 | 0.01 | 1 | 0.5 | 2.5 |
| Toluene | 0.54 | 0.5 | 0.51 | 0.06 | 10 | 50 | 150 |
| Hexane, n- | 300 | 4.3 | 0.54 | 0.06 | 10 | 50 | 150 |
| Heptane, n- | 45 | 2.8 | 0.8 | 0.28 | 50 | 400 | 500 |
| Styrene | 0.45 | 0.4 | 0.42 | 0.06 | 10 | 20 | 40 |
| Acetone | 1.2 | 1.1 | 1.4 | 0.28 | 50 | 750 | 1000 |
| Isopropanol | 500 | 6 | 2.7 | 0.28 | 50 | 400 | 500 |
| None | 1 | 1 | 1 | 0.00 | 0 | 1 | |
| Mixture Value: | 2.1 | 1.5 | 0.89 | 1.00 | 181 | 56 | 172 |
| TLV Alarm Setpoint when Calibrated to Isobutylene: | 26 ppm | 37 ppm | 62 ppm | | ppm | ppm | ppm |
| STEL Alarm Setpoint, same Calibration | 86 ppm | 115 ppm | 193 ppm | | | | |



TECHLAW STANDARD OPERATING PROCEDURES

FIELD PROCEDURES - CHAIN-OF-CUSTODY

Page 1 of 10
SOP Number: 02-05-03
Effective Date: 03/01/11

Technical Approval: _____ Date: 3/1/11

QA Management Approval: _____ Date: 3/1/11

SOP Description

This Standard Operating Procedure (SOP) describes the steps that are to be taken to ensure a correct Chain-Of-Custody (COC) program is followed for every TechLaw project involving sampling activities. The program allows for the tracking of possession and handling of individual samples, from the time of field collection through laboratory analysis. Because samples collected during an investigation could be used as evidence in litigation, possession of the samples must be traceable from the time each sample is collected until analytical results are introduced as evidence in legal proceedings.

This SOP must be used in conjunction with the procedures for packaging and shipping samples as discussed in SOP No. 04-02-XX, Environmental Samples, and SOP No. 04-03-XX, *Hazardous Materials/Dangerous Goods*.

General Procedures

Related SOPs

This SOP is to be used in conjunction with the other relevant or applicable SOPs found in the following SOP categories:

| <u>Category No.</u> | <u>Category Title</u> |
|---------------------|---|
| 02 | Field Procedures |
| 03 | Field Documentation Procedures |
| 04 | Packaging and Shipping Procedures |
| 05 | Field Equipment Operation and Maintenance Procedures |
| 06 | Groundwater Sampling/Monitoring and Analysis Procedures |
| 07 | Soil/Sediment Sampling and Analysis Procedures |
| 08 | Surface Water Sampling and Analysis Procedures |
| 09 | Health and Safety Procedures |
| 10 | Regulatory Compliance Procedures |
| 11 | Quality Assurance Procedures |
| 12 | Incineration/BIF Sampling and Analysis Procedures |

| | |
|----|--|
| 13 | Waste Sampling and Analysis Procedures |
| 14 | Asbestos Handling |
| 15 | Region 5 ESAT-Specific SOPs |
| 16 | Region 8 ESAT-Specific SOPs |

Equipment and Apparatus

- Sample identification labels
- Sample tags (with strings attached)
- Custody seals
- Chain-Of-Custody Records
- Receipt For Samples forms
- Ice chests and ice for sample shipment
- Nylon-reinforced strapping tape
- Clear (packing/strapping) tape
- Plastic zip-lock storage bags
- Pens with permanent water-proof ink
- Large trash bags to line the ice chest (cooler)
- Packaging materials (e.g., vermiculite, bubble wrap, saw dust, etc.)

Additional equipment and apparatus when using FORMS II Lite

- Computer, preferably with internet access
- Three-in-one portable printer
- Sticker labels for printing (such as Avery labels for printing)

Definitions

Sample under Custody

A sample is considered to be “under custody” if one or more of the following criteria are met:

- The sample is in the sampler's or the transferee's actual possession,
- The sample is in the sampler's or transferee's view after being in his/her possession,
- The sample was in the sampler's or transferee's possession and then was locked up in a secure place to prevent tampering, and
- The sample is placed in a designated secure area.

Sampler

The sampler is defined as the person responsible for the collection of the samples. Any person on the sampling team may serve as the sampler.

Transferee

The transferee is the person designated to receive and maintain custody of the samples and coordinate shipment of the samples from the site of collection to the analytical laboratory. Any person on the sampling team may serve as the transferee. In addition, the role of the transferee may be filled by several different people throughout the course of the sampling activities. The basic function of the transferee is to assume the responsibility of custody of the samples from the time the samples are collected until they are relinquished to the shipping company or the analytical laboratory.

Description of Chain-Of-Custody Forms

The COC process requires that specific COC forms and paperwork be prepared to document custody of the samples, from the time they are collected in the field until received by the analytical laboratory. A brief description of each of the forms and/or paperwork follows:

- **Sample Identification Label** - A sample identification label is affixed to each sample container to prevent misidentification of the samples after collection. The labels are usually self-adhesive and are affixed to the sample containers by placing them directly on the container exterior. Information to be provided on each label includes the site identification¹, date, time, preservative used (if any), type of analysis to be performed, name of sampler, and sample control number. The information should be recorded using permanent water-proof ink. The sample labels can be affixed to the sample containers either immediately before or after the sample collection activities. However, care must be taken to ensure that the containers are not mislabeled if the labels are applied after the samples are collected.

Sample identification labels are usually provided along with the shipment of sample containers, however, they can also be purchased separately. Sample containers and labels may be acquired from either the laboratory contracted to perform the analytical work, or from an independent source. Examples of sample identification labels are provided in Attachment A.

- **Sample Tag** - A sample tag may also be used to identify samples collected in the field. Requirements for using sample tags will be discussed in the QAPP or SAP. A sample tag consists of an identification label which is tied to the neck of the sample container. Information to be provided on each sample tag includes the project code, sample station number, the date and time of sample collection, type of sample (e.g., grab or composite), sample station location, the samplers' signatures, whether or not a preservative was added, type of analysis to be performed, tag number, and lab sample number. A copy of a sample tag is provided in Attachment B.
- **Custody Seal** - A custody seal is affixed over each sample container and lid to provide evidence that the sample was not tampered with during transport to the analytical laboratory. The custody seals are self-adhesive and should be placed such that they cover the sample containers and lids and sample tag strings, but not the writing on the sample labels. The custody seals may contain the date and signature of the sampler; provide space to include the sample number; the name of the individual who breaks the seal; and, the date that the seal is broken. Care must be taken to ensure that all sample identification characters are transcribed correctly on all related documents. Custody seals are also used to

¹ *Under no circumstances is it acceptable to provide the laboratory with the name, location or other identifying information for the site (this includes listing facility information on the chain-of-custody).* Facility initials, TechLaw project number or other identifier should be used that will not reveal facility information to the laboratory, but will be evident to TechLaw employees involved with the project.

secure the sample shipping containers and lids. Examples of custody seals are provided in Attachment C.

- **Chain-Of-Custody Record** - A COC Record is used to track and document sample possession from the time of collection until receipt at the analytical laboratory. A completed form must be filled out to accompany each shipment of samples to the laboratory. Information to be recorded on the form may include: the project number, project name²; name and address of analytical laboratory; samplers' names and signatures; date and time of sample collection; sample identification numbers; sample description; type of preservative; grab or composite; number of containers included in the shipment; analytical parameters requested; and, sample tag number (if applicable). The bottom portion of the form contains blocks for the signatures of the persons involved in the chain of possession, including dates of possession, and any pertinent remarks. A copy of a COC Record form is provided in Attachment D.
- **Receipt For Samples Form** - RCRA Section 3007 and CERCLA Section 104 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. A Receipt For Samples form may be used to satisfy these requirements. In addition, the form may also be used to document that split samples were offered to, and were accepted or rejected by, the owner/operator of the facility, as well as documenting this in the field logbook. A COC Record may also be used to document the collection of split samples and may substitute for the Receipt for Samples form. Information to be entered on the form includes: the project number and name; facility name and location; samplers' signatures; sample station number and description; date and time of sample collection; type of samples collected (e.g., groundwater or soil; grab or composite); sample tag numbers; number of containers; any pertinent remarks; and the signatures of the persons involved in the chain of possession. A copy of a Receipt for Samples form is included as Attachment E.

Chain-Of-Custody Procedures

The field sampling team is responsible for the care and custody of all field samples from the time of collection until shipment to the analytical laboratory. The specific COC procedures to be followed for each sampling event are listed below.

² *Under no circumstances is it acceptable to provide the laboratory with the name, location or other identifying information for the site (this includes listing facility information on the chain-of-custody).* Facility initials, TechLaw project number or other identifier should be used that will not reveal facility information to the laboratory, but will be evident to TechLaw employees involved with the project.

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- The sampling team should collect samples in the field such that the most sensitive parameters are addressed before the less sensitive parameters (e.g., volatile organic samples should be collected prior to metals, cyanide, and other parameters). Refer to the SOP "06-," "07-," and "08-," "12-," and "13-" series for specific sampling procedures for groundwater, soil/sediment, surface water, incineration/BIF, and waste, respectively.
- Each sample container should be filled with the sample, and then placed in an ice chest which contains bagged ice.³ All environmental sample containers must be placed in the ice chest immediately after collection to preserve the integrity of the sample parameters. The ice chest with the samples must remain in view of the samplers in order for the samples to remain in custody.
- After all sample parameters have been collected at a specific sample location, the sampling team travels back to the central staging area, relinquishes control of the samples to the transferee for safekeeping, and prepares for the next sampling location. If only two field samplers are present, samples must be placed on ice and locked in a secure location (e.g., vehicle) before departing for the next sample location.
- The transferee (or other field team members, as appropriate) should inspect the sample containers to ensure they were properly filled and secured. Any problems observed with the sample containers (e.g., broken glass containers, sample bottles not adequately filled, loose lids) should be completely documented in the field logbook.
- If not already affixed, the transferee/field team members should apply sample identification labels and/or sample tags to the sample containers. A layer of clear (packing/strapping) tape may be placed directly over each sample label to prevent the ink from smearing and slippage of the label due to condensation on the outside of the container. After the sample containers have been labeled/tagged, the transferee may secure each sample with custody seals. Samples are then placed into plastic zip-lock type bags. Large sample containers (e.g., one-gallon amber glass jugs) do not need to be placed into plastic bags. The sample containers are then returned to the ice chest.
- After all samples have been collected and the containers appropriately labeled, the transferee then completes the COC Record. If necessary, the transferee and/or sampling team members transfer the sample containers from the sample storage ice chest into the sample shipping container (which may be a different ice chest). The transferee/team

³ Only environmental samples should be preserved with ice; waste samples are never shipped with ice. Refer to SOP No. 04-02-XX for more information regarding the packaging and shipping procedures for environmental samples.

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members must ensure that the samples are properly packaged within the shipping container. Refer to SOP No. 04-02-XX for sample packaging and shipping procedures.

- The original and at least one copy of the COC Record must be placed inside a plastic zip-lock type storage bag and taped to the underside (interior) of the shipping container lid. One copy of the COC Record must be retained by the transferee for placement into the project files.
- The sample shipping container should then be closed and secured with several layers of strapping tape at each end of the shipping container. At least two custody seals must be placed along the front and back edges of the container, where the container body and lid meet. The custody seals should be affixed such that the shipping container cannot be opened without tearing or disturbing the seals. Secure the seals by covering them with tape. The seals should be secured to prevent their accidental removal during shipment. Only one layer of tape should cover the seals to ensure that they remain visible through the tape.
- The shipping airbill should then be completed and attached to the shipping container. The transferee (or other sample team member as designated by the transferee) must personally deliver and release the shipping container to the shipping company or the analytical laboratory.
- If it is not possible to release the sample shipment to the shipping company, or if the samples must be retained overnight, the transferee or designated custodian must maintain custody of the samples until the shipment can be accomplished. Custody is maintained provided that the samples:
 - Remain in the transferee's actual possession.
 - Remain in the transferee's view after being in his/her possession.
 - Are locked up in a secure place to prevent tampering.
 - Are placed in a designated secure area.

If the shipping delay is of a short duration (less than twenty-four hours in most circumstances), the shipping container should remain closed and sealed. The actual release time to the shipping company should then be entered in the field logbook. If the delay time is of a longer duration, or the conditions where the samples are stored are likely to lead to loss of ice (i.e., if the samples are kept in a locked vehicle on a hot day), the shipping container should be re-opened and additional ice added to the container. In addition, the laboratory should be contacted and informed of any pending shipping delays.

FIELD PROCEDURES - CHAIN-OF-CUSTODY

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- Prepare a Receipt For Samples form or a COC form and present it to the facility representative prior to departing the facility. Document in the field logbook whether split samples were offered to, and were accepted or rejected by, the facility representative. The transferee must keep one copy of the Receipt For Samples form or COC form for inclusion in the project files.
- Document all field sampling and shipping activities, and COC procedures in the field logbook and photographic record. In addition, any COC deviations from the SAP or this SOP must be documented and justified in the field logbook. Field logbook and photographic log documentation procedures can be found in SOP Nos. 03-01-XX and 03-02-XX, respectively.

The above COC procedures are guidelines that should generally be followed by TechLaw field personnel. However, the site-specific SAP and QAPP should identify any specific requirements based on project or contract requirements. For EPA Superfund contracts, it is often necessary to send the samples to a Superfund's Analytical Services Branch (ASB) Contract Laboratory Program (CLP) Routine Analytical Services (RAS). When a CLP lab is the designated recipient of the samples, the Field Operations Records Management System II Lite (FORMS II Lite) should be used to generate labels, COCs and traffic reports (TRs).

FORMS II Lite is a program that helps automate the field sampling documentation process. Computer-based and web-based training is available at the following web page: <http://epa.gov/superfund/programs/clp/f2ltrain.htm>. All field personnel are encouraged to take this training.

FORMS II Lite proceeds through a series of logical steps to allow the user to input information. It contains seven steps which ultimately lead to the creation of labels and records. The seven steps are listed below.

- Step 1: Enter Site Information
- Step 2: Select Sampling Team
- Step 3: Select Analysis
- Step 4: Station/Location
- Step 5: Assign Bottles
- Step 6: Assign Lab

Step 7: Assign Carrier

Initiating a project is done in Steps 1 through 3; sample locations are identified in Step 4; numbering and documenting samples is accomplished in Step 5; and shipping information is generated in Steps 6 and 7.

FORMS II Lite generates a Regional COC, which should be sent to the EPA Region that owns the contract under which the sampling is conducted. Depending on the EPA Regional requirements, the following actions may be required after the samples are shipped in accordance with the above general procedures.

- Upload the TR/COC to the EPA Sample Management Office (SMO) website (you should have had exported the TR as an .xml file before executing this action). Access to the SMO website will require a User Name and Password and should be obtained from the TechLaw Project Manager or the EPA Project Manager in advance.

The SMO website address is: <http://epasmoweb.fedcsc.com/scstr/>

- Submit the Regional COC/TR to the EPA Region. In some Regions (e.g., Region 3), a scanned (PDF) version of the COC/TR vial email is an acceptable form of submittal. Check with your Region whether email or fax of the COC/TR is acceptable in lieu of shipping the original to the Region.

Health and Safety Section

It is TechLaw's policy to maintain an effective program for control of employee exposure to chemical, radiological, and physical stress which is consistent with OSHA and other applicable and appropriate established standards and requirements.

All field personnel will be provided with appropriate personal protective clothing and safety equipment. At a minimum, this will include a hardhat, hearing protection, full-face respirator, steel-toed safety shoes, and safety glasses. Personnel are required to inspect their PPE prior to entering any job site and replace any damaged items.

A site-specific health and safety plan must be developed by the field team leader or designee and approved by the TechLaw Health and Safety Director prior to implementation in the field. This plan must be reviewed with the field team members prior to beginning work.

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FIELD PROCEDURES - CHAIN-OF-CUSTODY

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Any deviation(s) from an approved site-specific health and safety plan must be documented in the field logbook.

QA/QC Section

None at this time.

Comments/Notes

None at this time.

Attachments

Attachment A - Sample Identification Labels (examples)

Attachment B - Sample Tag (examples)

Attachment C - Custody Seals (examples)

Attachment D - Chain-Of-Custody Record (examples)

Attachment E - Receipt For Samples Form (examples)

References

TechLaw, Corporate Quality Management Plan, most current revision.


TechLaw, Health and Safety Program, most current version.

TECHLAW STANDARD OPERATING PROCEDURES

ATTACHMENT A [Revised 03/01/11]

SOP Number: 02-05-03

SAMPLE IDENTIFICATION LABELS

| | | |
|---|-------|--|
| EAGLE  PICHER ENVIRONMENTAL SERVICES 36 B. J. TUNNELL BLVD. - MIAMI, OK 74354 1-800-331-7425 | | Specially Cleaned Sample Container LOT NO.: |
| DATE: | TIME: | COLLECTED BY: |
| SAMPLING SITE: | | |
| SAMPLE TYPE: <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Other | | |
| TESTS REQUIRED: | | PRESERVATIVE |

| | |
|-----------------|------------------|
| Client | _____ |
| Project | _____ |
| Location | _____ |
| Station | _____ |
| Collected by | _____ |
| Date | _____ Time _____ |
| Preservative(s) | _____ A PEST |
| EA 0447 3/22/89 | |

TECHLAW STANDARD OPERATING PROCEDURES

ATTACHMENT B [Revised 03/01/11]
SOP Number: 02-05-03

SAMPLE TAG



| | | | | |
|------------------------------|---------------------------------|--|------------------------------|-----------------------------|
| Designator: | Grab | Station Location Stationers (Signatures) | Preservative: _____ | |
| | Comp. | | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| Time | Volatile Organics (VOA) | | | |
| | Semi Volatiles (ABN) | | | |
| | Pesticides/PCB | | | |
| Month/Day/Year | _____ Metals | | | |
| | Cyanide | | | |
| | Alkalinity/Hardness | | | |
| Station No. | TCLP | | | |
| | <input type="checkbox"/> VOA | | | |
| | <input type="checkbox"/> ABN | | | |
| Project Code CLP Case No. | <input type="checkbox"/> METALS | | | |
| | Asbestos | | | |
| | Dioxin | | | |
| | | Oil and Grease | | |
| | | | | |
| | | Remarks: | | |
| | | Concentration: | | |
| | | <input type="checkbox"/> L <input type="checkbox"/> M <input type="checkbox"/> H | | |
| | | Tag Number | Lab Sample No. | |
| | | 6-215951 | | |


☆ U.S.GPO:1996-761-527

TECHLAW STANDARD OPERATING PROCEDURES

ATTACHMENT C [Revised 03/01/11]

SOP Number: 02-05-03

CUSTODY SEALS

| | | | | |
|---|---|------|------------------------|------------------------------|
|  UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OFFICIAL SAMPLE SEAL | SAMPLE NO. | DATE | SEAL BROKEN BY DATE | EPA FORM 7500-2 (Rev. 79) |
| | SIGNATURE | | | |
| | PRINT NAME AND TITLE (Inspector, Analyst or Technician) | | | |

| | | |
|---|---|--|
|  UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OFFICIAL SAMPLE SEAL |  UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OFFICIAL SAMPLE SEAL | CUSTODY SEAL _____ Date _____ Signature |
|---|---|--|

CUSTODY SEAL

DATE _____

SIGNATURE _____



[illegible]

TECHLAW STANDARD OPERATING PROCEDURES

ATTACHMENT E [Revised 03/01/11]

SOP Number: 02-05-03

RECEIPT FOR SAMPLES FORM

[illegible]

TECHLAW STANDARD OPERATING PROCEDURES

FIELD DOCUMENTATION PROCEDURES - MAINTAINING A FIELD LOGBOOK

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SOP Number: 03-01-04
Effective Date: 03/01/11

Technical Approval: _____ Date: 3/1/11
QA Management Approval: _____ Date: 3/1/11

SOP Description

This Standard Operating Procedure (SOP) establishes general practices and requirements for the use of field logbooks during environmental field activities, including, but not limited to, soil/sediment sampling, groundwater sampling, well installations, surface water sampling, environmental assessments, and environmental audits. SOPs for the use of field logbooks during RCRA Visual Site Inspections and oversight of RCRA Facility Investigations and Remedial Investigations are provided in SOP Nos. 03-03-XX and 03-04-XX, respectively.

Logbooks are used by personnel to document all activities and information gathered in the field. The field logbook entries must be legible, factual, detailed and objective. Proper field documentation is crucial in the logbook because the logbook ultimately may become part of the public record and may be used in future legal actions. The field logbook must provide sufficient documentation to enable participants to reconstruct events that occurred and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings.

General Procedures

Related SOPs

This SOP is to be used in conjunction with other relevant or applicable SOPs found in the following SOP categories:

| <u>Category No.</u> | <u>Category Title</u> |
|---------------------|---|
| 02 | Field Procedures |
| 03 | Field Documentation Procedures |
| 04 | Packaging and Shipping Procedures |
| 05 | Field Equipment Operation and Maintenance Procedures |
| 06 | Groundwater Sampling/Monitoring and Analysis Procedures |
| 07 | Soil/Sediment Sampling and Analysis Procedures |
| 08 | Surface Water Sampling and Analysis Procedures |

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| | |
|----|---|
| 09 | Health and Safety Procedures |
| 10 | Regulatory Compliance Procedures |
| 11 | Quality Assurance Procedures |
| 12 | Incineration/BIF Sampling and Analysis Procedures |
| 13 | Waste Sampling and Analysis Procedures |
| 14 | Asbestos Handling |
| 15 | Region 5 ESAT-Specific SOPs |
| 16 | Region 8 ESAT-Specific SOPs |

Equipment and Apparatus

- Field logbooks (Minimally one per person.)
- Black or Blue pens with waterproof ink (preferably)
- Compass (preferably)
- Watch

Type of Field Logbook

The field logbook must be bound and preferably waterproof. A standard surveyor's notebook or the "Rite in the Rain"® Weatherproof Transit Book No. 300, J.L. Darling Corporation, Tacoma, Washington, are types of acceptable notebooks that can be used by TechLaw personnel. Other notebooks are acceptable, provided that they are bound prior to use in the field. A supply of field notebooks should be kept in each office location.

Maintenance of Field Logbook

The Field Team Leader is responsible for the field logbooks. Each field team member may be required to maintain a field logbook; in addition, the Field Team Leader may designate a team member as the official record keeper. To ensure consistency in documentation, each logbook is to be maintained by the same person for the duration of the project, if feasible. The Field Team Leader must review the logbooks during the environmental field activities to check that the procedures in this SOP are being followed and that the information is entered correctly. Additionally, it is the responsibility of the Field Team Leader to ensure that RCRA CBI procedures are followed if confidentiality is requested by the facility representative.

TECHLAW STANDARD OPERATING PROCEDURES

FIELD DOCUMENTATION PROCEDURES - MAINTAINING A FIELD LOGBOOK

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Notations in Field Logbook

- All notations in field logbooks should be made in waterproof ink. A standard ball-point pen is acceptable. No erasures may be attempted. Any corrections or deletions are to be made by drawing a single line through the unwanted notation, so that the notation is still legible. The writer then places his/her initials and the date near the deletion. Under no circumstances are pages to be removed from a field logbook.
- All field logbook notations must be legible.
- A separate field logbook must be used for each project. More than one logbook may be used for a single project if the complexity of the site requires that two separate field teams are active on different parts of the facility simultaneously. If more than one logbook is used, each is to be numbered sequentially (e.g., 1 of 3, 2 of 3, 3 of 3). If two or more separate field teams are maintaining logbooks, each team's logbooks are to be numbered sequentially and clearly identifiable (e.g., Team A Book 1 of 2, Team A Book 2 of 2, Team B Book 2 of 2). Each page of the field logbook must be numbered. Each page also must be dated and signed by the writer. For pages only partially filled with text, a diagonal line must be drawn from the end of the text to the bottom of the page. When field activities last more than one day, the next day's documentation begins on the next page of the field logbook. Relevant site information (e.g., weather, site personnel [personnel could change during the course of the field work], strategies) must be listed at the beginning of each day's activities. Also, more than one team member may maintain a logbook, at the discretion of the team leader. The maintenance of a logbook is discussed in more detail in the appropriate Field Documentation SOP (e.g., RCRA VSI, Field Oversight).
- The individual maintaining the logbook must put his/her name and contact information on the inside cover or the first (title) page of the logbook. The first page must include the title of the project, project number, facility name, facility location, EPA Identification Number (if appropriate), date(s) of activity, names and companies of the team members and any other appropriate identifying information. If more than one field logbook is used at a facility, each must contain the required project information on the inside cover or the first (title) page of the logbook.

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FIELD DOCUMENTATION PROCEDURES - MAINTAINING A FIELD LOGBOOK

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- Information is generally listed in chronological order in the field logbook and by the time of day. All times are to be entered in a 24-hour format (e.g., 7:00 p.m. is 1900). All factual information obtained during field activities must be recorded in the logbook. Information that is not in or referred to in the logbook may not be used in deliverables associated with the field work. The field logbook contains only factual information--no conclusions are placed in the logbook. Weather conditions are documented at least twice a day and must be noted immediately with any significant weather change (e.g., thunderstorm).

Often, sketches are preferred to written descriptions (or used in conjunction with), especially where photographs will not be taken. Sketches must include a north arrow, a rough scale and position of buildings, and any other notable features, such as landmarks (trees, streets etc.).

When photographs are taken, the photograph number is entered into the logbook as well as time of day, compass direction, and a description of what was photographed. Relevant features such as cracks and staining should be documented. See SOP No. 03-02-XX, Taking and Documenting Photographs, for further details.

- The field logbook is the property of the client¹. The project manager is the custodian of the field logbook for the duration of the project. It must remain in the custody of the project manager (or a designated person) until the conclusion of the field portion of the project. The field logbook is then turned over to the central files.
- Once a field logbook is filled up, the logbook should be scanned and a copy placed in the central files (electronic or hard copy) as soon as possible. Additionally, it is recommended that copies of previous logbooks, instead of original logbooks, are brought into the field to minimize the risk of losing hard copy logbooks.

¹ Work products such as field logbooks that are generated during the performance of government contracts are considered the property of the government client. See SOP No. 11-06-XX for further details regarding document control requirements.

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FIELD DOCUMENTATION PROCEDURES - MAINTAINING A FIELD LOGBOOK

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Health and Safety

It is TechLaw's policy to maintain an effective program for control of employee exposure to chemical, radiological, and physical stress which is consistent with OSHA and other applicable and appropriate established standards and requirements.

All field personnel will be provided with appropriate protective clothing and safety equipment. At a minimum, this will include steel-toed shoes, safety glasses, and chemical-resistant gloves.

A site-specific health and safety plan must be developed by the Field Team Leader or designee and approved by the TechLaw Health and Safety Director prior to implementation in the field. This plan must be reviewed prior to beginning work.

Any deviation(s) from an approved site-specific health and safety plan must be documented in the field logbook.

QA/QC

The Field Team Leader or designee is to conduct periodic QC reviews during a site visit to ensure documentation procedures and administrative requirements have been met.

Comments/Notes

None at this time.

Attachments

None at this time.

References

TechLaw, Corporate Quality Management Plan, most current revision.

TechLaw, Health and Safety Program Plan, most current version.

TechLaw, Security Plan for the Control of Confidential Business Information, most current version.

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U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Facility Assessment Guidance, October 1986.

TECHLAW STANDARD OPERATING PROCEDURES

FIELD DOCUMENTATION PROCEDURES - TAKING AND DOCUMENTING PHOTOGRAPHS

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SOP Number: 03-02-04
Effective Date: 03/01/11

Technical Approval: _____ Date: 3/1/11

QA Management Approval: _____ Date: 3/1/11

SOP Description

This Standard Operating Procedure (SOP) establishes the practice and requirements for documenting and taking photographs during field activities, including: RCRA Visual Site Inspections (VSIs), oversight of RCRA Facility Investigations (RFIs), oversight of Remedial Investigation/Feasibility Studies (RI/FSs), compliance enforcement inspections (CEIs), comprehensive groundwater monitoring evaluations (CMEs), conduct of sampling activities, and property transfers.

The purpose of these activities is to gather sufficient information and documentation to relay observations to the client and to provide the basis for suggestions for further action or recommendations.

Photographs are taken to obtain visual information concerning unit characteristics, waste characteristics, pollutant migration pathways, releases, and exposure potential. Critical documentation is important because these photographs may eventually be used in enforcement/defense cases, legal actions (as evidence of past releases), or as a basis for property transactions. The photographs could be used months or years later, and must be thoroughly documented.

This SOP indicates the type of information that must be recorded in the field logbook in conjunction with the type of items that must be photographed. The photograph log serves as a visual record of what was seen during the field activities.

General Procedures

Related SOPs

This SOP is to be used in conjunction with other relevant or applicable SOPs found in the following SOP categories:

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| <u>Category No.</u> | <u>Category Title</u> |
|---------------------|---|
| 01 | General Procedures |
| 02 | Field Procedures |
| 03 | Field Documentation Procedures |
| 04 | Packaging and Shipping Procedures |
| 05 | Field Equipment Operation and Maintenance Procedures |
| 06 | Groundwater Sampling/Monitoring and Analysis Procedures |
| 07 | Soil/Sediment Sampling and Analysis Procedures |
| 08 | Surface Water Sampling and Analysis Procedures |
| 09 | Health and Safety Procedures |
| 10 | Regulatory Compliance Procedures |
| 11 | Quality Assurance Procedures |
| 12 | Incineration/BIF Sampling and Analysis Procedures |
| 13 | Waste Sampling and Analysis Procedures |
| 14 | Asbestos Handling |
| 15 | Region 5 ESAT-Specific SOPs |
| 16 | Region 8 ESAT-Specific SOPs |

Equipment and Apparatus

- Digital or 35 mm-type camera (If it is a large facility, two cameras may be necessary.)
- Extra batteries
- If 35 mm-type camera is used, 200 ASA speed film, 24 exposures (minimum)
- Compass (preferably)
- Watch
- Ruler/pen/coin (to illustrate scale)

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Permission to Take Photographs

When conducting field activities, obtain permission to take photographs from the facility representative prior to the field activities. If there is an appearance of resistance from the facility representative, inform the client and together develop a course of action/strategy to obtain resolution prior to the field activities. In addition, it is the responsibility of the Field Team Leader to ensure that CBI procedures are followed if confidentiality is requested by the facility representative.

Maintenance of the Camera

The following generic operating and maintenance activities must be performed in accordance with specific directions provided with the camera.

- Routine inspection and cleaning are to be conducted prior to the field activities. If unfamiliar with the type of camera, review the general directions provided by the manufacturer. However, prior to field activities, ensure familiarity with such "how to" procedures as:
 - Insert and check the battery
 - Load and rewind the film, if applicable
 - Set the film speed, if applicable
 - Clear memory card, if applicable
 - Set the clock
- Routine testing of batteries must be conducted prior to the field activities and at the beginning of each day in the field. Additional spare camera batteries should be on hand.
- Remedial action in the event of failure or malfunction must be in accordance with the camera warranty (if applicable) and directions for troubleshooting. A malfunction can be caused by shock, humidity, salt, etc. If a camera has been used in the presence of chemicals, it is to be wiped clean. Also, film cameras must not be placed near strong magnetic fields.

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General Information Regarding Cameras and Film

Camera Types

Each TechLaw field-ready office location should have a digital and/or 35 mm automatic-focusing/automatic-winding camera or access to one. See SOP No. 02-07-XX for details regarding equipment acquisition, inventory and maintenance if more than one camera is needed. These cameras are relatively simple to use since they do not require manual focusing or shutter speed adjusting. This is advantageous since the photographer may also be tasked with recording the photograph description and picture number, as well as asking questions regarding the purpose of the unit being photographed. These cameras should have an internal clock which records the date and/or time the photograph was taken. Setting the clock is important because it provides additional documentation and also helps in organizing the photographs. The date is a priority. If you can include both settings (i.e., date and time), this is preferred.

Types and Quantities of Film Needed

If a 35 mm type camera is used, the recommended film is 200 ASA speed and 24 exposures (minimum). A sufficient number of rolls of film must be taken on field activities. Since the film rolls are small, a good rule of thumb is to take two rolls for every 10 units or SWMUs identified prior to the field activities. Alternatively, take two rolls for every 25 acres of the site. For sampling visits, one roll for every 6 samples may be sufficient. This would allow for 4 pictures per sample location using a 24-exposure roll. Typical photographs would include one overview, one closer view of the sample collection, one of the filled sample containers, and one extra for other documentation needs. Take as many rolls as you think you will need and then add two as a safety margin. The unused film must be returned to the office.

Quantity of Memory Needed

If a digital camera is used, the camera's memory card should allow for a sufficient number of photographs. Before commencing field activities, it should be ensured that the memory will meet the project needs using the guidelines for film cameras in the section above. If camera memory becomes an issue on site, lower resolution settings can be used.

Treatment and Shipment of Camera and Film

Cameras and film generally are not affected by the X-ray machines at airport security check stations. However, the X-ray machine will have an effect if the film speed is 1000 ASA or if the film is repeatedly exposed to the X-rays (going through the X-ray machine more than four times).

There are no special shipment procedures for the camera or film. The camera and unexposed film can be packed and checked in the suitcase of the field personnel or shipped in an ice chest with other field equipment. In order to prevent loss, it is recommended that the camera's memory card and/or the exposed film rolls be carried onto the plane and kept in one's possession at all times.

Commonly, there will be unexposed photographs on the last roll of film in the camera. Automatic cameras typically do not allow for rewinding the film until all photographs are taken. One option is to open the shutter, place your hand over the lens and shoot the remaining photographs. These will appear as black negatives and usually there is no charge for processing these. Alternatively, photographs of surrounding areas, such as waterways and residences, or overviews of the facility can be taken in order to complete the roll.

Types and Subjects of Photographs

- During field activities, the Field Team Leader selects one team member to take photographs and record the appropriate information in the field logbook. Photographs must be taken of each unit or SWMU identified unless the facility representative denies permission for that particular unit. In these cases, the refusal is to be documented in the field logbook.
- Photographs are taken to document conditions at the facility or sampling activities. The types of pictures taken must include:
 - Representative overall pictures of the facility or site;
 - Posted signs identifying ownership of the facility or site;
 - Evidence of releases (e.g., leachate seeps, pools of liquid, discolored water, and stained soils);
 - Individual units such as lagoons, drums, and landfills;

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- Visual evidence of poor facility maintenance;
 - Examples of typical facility operation;
 - Adjacent land use;
 - Sample locations/activities; and
 - Areas that unauthorized persons can easily access.
- Information that must be recorded in the field logbook in conjunction with each photograph includes:
- Photographer's name;
 - Type of camera (e.g., digital or 35 mm);
 - Type of film (if applicable);
 - Photograph number;
 - Date and time;
 - Name and identification number of unit or SWMU;
 - Location of unit or SWMU;
 - Orientation of photograph (i.e., direction photographer is facing);
 - Observed evidence of release (e.g., staining, overflow);
 - Notable features of unit or SWMU that may provide evidence of release (e.g., cracking, obvious lack of integrity of unit);
 - Information to help characterize the unit, or picture; and
 - Other comments (e.g., weather, if a zoom lens was used, etc.).
- When photographs are taken of objects that are small or close up, it is often helpful to use a ruler, pen or coin in the frame to illustrate the scale so one will be able to more easily explain or describe the dimensions or proportions.
- During sampling activities, photographs are to be taken of actual sample collections, conditions of sampling location (e.g., monitoring well head and pad, soil sampling location with respect to surroundings), filled sample containers, and the chain-of-custody seals on the closed and sealed ice chests.
- For engagements conducted for regulatory agencies or in the case of property transactions, permission to take photographs must be obtained from the owner/operator of the facility. Inform the owner/operator that you will point out or explain what you would like to photograph before you actually take the photographs.

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Listed below are three possible scenarios, in order of preference, by which photographs are taken and processed:

- You take the photographs using the TechLaw camera and leave with the film and/or photograph files.
- If permission for you to take the photographs is denied, negotiate with the owner/operator to have them take the photographs using the TechLaw camera.
- The least desirable approach is when permission to take the photographs is denied, or the facility allows you to take the photographs but will not let you leave with the memory card and/or roll(s) of film. In these cases, negotiate with the owner/operator to have the photographs processed, review them, and provide the required number of copies and negatives (if applicable) to you. In these cases, the client (e.g., EPA) must be aware of these arrangements and approve them. Note: There have been instances where photographs were taken by the owner/operator, but were never provided to TechLaw.

Development/Handling of Photographs and Negatives, and Compact Disks

Commercial developing facilities may be utilized for processing digital photos and/or 35 mm film. A minimum of two 4x6 copies of each photograph must be requested - one for submittal to the client and the other for the TechLaw files. Prior to processing, determine how many copies of the photographs are needed through discussions with the client or Project Manager. For example, some clients require two copies; therefore, in order to have a set for the TechLaw files, three copies must be made. On occasion, the facility will request a copy of the photographs. If the client is a regulatory agency (e.g., EPA), this must be approved by the regulator prior to providing the photographs to the facility. Under no circumstances must the original negatives and/or compact disks be sent to or left with the facility. Financial reimbursement must be agreed to prior to photographic duplication. At the end of the assignment, the negatives and/or compact disks are forwarded to the Program Manager or designee for inclusion in the central files.

In instances where a facility requests that the photographs be treated as CBI (or some other form of confidentiality), the photographs and negatives must be designated, logged, handled, stored, and transmitted in the same manner as any other CBI material.

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Photo Log

The purpose of a photo log is to present the photographs taken during field activities along with brief documentation describing them. Each write-up is to provide the name and number of the unit (e.g., Storage Tank 11, SWMU 3), a description of the unit or activity, and the compass direction. Note any particular background items that should be brought to the attention of the reader (e.g., note the absorbent materials on the floor around the drum). Notations should be limited to pertinent facts. The photo log format may vary depending upon the client's instructions. Two examples are provided in Attachment A.

In addition, maps and drawings (which contain a scale and compass points) can be appended to provide further clarification of the photographs and field logbook entries. Notations can be made on the maps showing where the photographs were taken and in what compass direction, as well as the number on the roll of film (if applicable).

If any post processing (e.g., cropping or zooming) is done to digital photographs, this must be noted in the photo log. The original print, as well as the post-processed print should be provided to the client. Also, if post-processing is conducted, both the original photograph and the post-processed version must be placed on a CD-ROM or DVD-ROM in TechLaw's central files.

Health and Safety

It is TechLaw's policy to maintain an effective program for control of employee exposure to chemical, radiological, and physical stress which is consistent with OSHA and other applicable and appropriate established standards and requirements.

All field personnel will be provided with appropriate protective clothing and safety equipment. At a minimum, this will include steel-toed shoes, safety glasses, and chemical-resistant gloves.

A site-specific health and safety plan must be developed by the Field Team Leader or designee and approved by the TechLaw Health and Safety Director prior to implementation in the field. This plan must be reviewed prior to beginning work.

Any deviation(s) from an approved site-specific health and safety plan must be documented in the field logbook.

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QA/QC

None at this time.

Comments/Notes

Upon project completion, the logbook(s), one set of photographs and all negatives and/or compact disks must be forwarded to the central files.¹

Attachments

Attachment A - Photograph Log Example

References

TechLaw, Corporate Quality Management Plan, most current revision.

TechLaw, Health and Safety Program Plan, most current version.

TechLaw, Security Plan for the Control of Confidential Business Information, January 2006.

U.S. Environmental Protection Agency, A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, OSWER Directive 9355.0-14. Washington, D.C., 1987.

U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Characterization of Hazardous Waste Sites - A Methods Manual, Volume 1 - Site Investigations, EPA/600/4-84/075, Las Vegas, NV.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Facility Assessment Guidance, October 1986.

U.S. Environmental Protection Agency, Region IV, Environmental Service Division, Engineering Support Branch Standard Operating Policies and Procedures, Georgia, February 1991.

¹ Work products such as photographs and negatives that are generated during the performance of government contracts are considered the property of the client. See SOP No. 11-06-XX for further details regarding document control requirements.

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ATTACHMENT A [Revised 03/01/11]

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PHOTOGRAPH LOG EXAMPLE

1. Overview of finished monitoring well LF-2, facing southwest. Note drums containing drill cuttings are in contact with the soil.
2. Facing northeast towards finished monitoring well LF-2. Note the well casing has not been grouted around the surface. The drums contain drill cuttings.
3. View (looking east) of the Torit Dust Collector. Note the 55-gallon drums which receive the particulates that are removed from the indoor air. This is a representative unit for the other cyclones in the plant.
4. Close-up view of the Former Oil/Water Separator No. 13. This unit is presently operating as a catch basin for oily wastewater prior to piping to the Building 29-N 40,000-Gallon Oily Wastewater Tank (SWMU A-5).
5. View (looking east) of the removal pipe for Tank W-82. The Waste Oil Vacuum Truck (SWMU L-46) collects the waste oil/jet fuel at this point. Note the staining on and poor condition of the asphalt. The stained building in the background is a test cell.
6. View of Underground Waste Storage Tanks W-89 and W-92 after being exhumed. The hole was cut in the side of the tank to examine the metal for value as scrap. This is not the original location of these tanks.
7. View of surface access area to Underground Waste Oil Storage Tank W-50. Note the oil-stained pavement and absorbent in the area.
8. View (looking north) of the manhole and bermed access area to underground Waste Storage Tank W-53. Note oil staining on berm and in containment area.
9. View of rinsing split spoon sampler, in foreground, with the drill rig in the background. Note the driller in the background is not wearing gloves.
10. Underground Discharge Pipe. Close-up of the asphalt road covering the underground discharge pipe. The location of the pipe is indicated by the parallel cracking. Note: In the background are the former lagoons. View is facing west.

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ATTACHMENT A [Revised 03/01/11]

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Example

TECHLAW

Contract No. XX-XX-XXXX

[Insert Photo Here]

PHOTO #

SITE NAME/EPA ID # _____

SITE LOCATION _____

PHOTOGRAPHER/WITNESS _____

DATE _____ TIME _____ DIRECTION _____ TO# _____

COMMENTS _____

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ATTACHMENT A [Revised 03/01/11]

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A second procedure for photograph logs is by using Avery Labels #5163 (or similar). The completed photograph log labels are peeled and placed on the back of the appropriate photograph. The photographs are then placed into a clear plastic photograph storage sheet. See below for an example of the photograph log labels format:

Photo #T1-01 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1325

Tank 901A, labeled "Used Alkaline Storage".

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SE

Photo #T1-03 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1410

Drum located next to Tank 901A (just north). Note: no label is observed on the drum. Sample SUI05 collected from this drum.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SE

Photo #T1-05 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1445

Photo of sample jar for sample SUI01. Note: The sample jar is an amber color and does not reflect the color of the material inside.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SE

Photo #T1-07 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1515

Photo of Acid Tank. Sampling location for sample SUI04.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: NE

Photo #T1-02 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1405

Tank 901A. Note: dark material in secondary container. Location for Sample SUI01.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SW

Photo #T1-04 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1440

Photo of sample jar of sample SUI05. Note: The sample jar is an amber color and does not reflect the color of the material inside.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SE

Photo #T1-06 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1513

Photo of "Used Cyanide Storage" Tank 901B. This is the sample location of Samples SUI02 and SUI03.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SW

Photo #T1-08 City: Tulsa, OK
Site: Name Industries, Inc. Time: 1540

Photo of southern portion of the Covered Hazardous Waste Storage Area.

Photo By: Photographers Name Date: 2/24/07
Witness: Witness Name Direction: SE

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PACKAGING AND SHIPPING PROCEDURES - ENVIRONMENTAL SAMPLES

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SOP Number: 04-02-02
Effective Date: 03/01/11

Technical Approval: _____ Date: 3/11/11

QA Management Approval: _____ Date: 3/11/11

SOP Description

This Standard Operating Procedure (SOP) describes the procedures involved in the packaging and shipping of environmental samples.

It is the Field Team Leader's responsibility to determine whether the samples meet the definition of environmental or dangerous goods samples and to follow the appropriate packaging and shipping procedures - SOPs and related guidance. Assistance in determining sample categories can be obtained from senior TechLaw staff/managers.

Definitions:

- **Environmental Samples** - normally include drinking water, most groundwater and ambient surface water, soil, sediment, and any samples not containing high levels of hazardous materials or hazardous waste. These types of samples generally are not considered a hazardous waste in 40 CFR 261.3, or hazardous materials under the regulations in 49 CFR 171 through 178. These samples are taken from areas where high concentrations of constituents are not likely to be found.
- **Hazardous Material** - a substance or material, which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. The term includes hazardous substances (40 CFR 302.4), hazardous waste (40 CFR 261), marine pollutants (49 CFR 172.101, Appendix B), and elevated temperature materials (49 CFR 171.8).
- **Dangerous Good** - an article or substance, which is capable of posing a significant risk to health, safety, or property when transported by air, and which meets the criteria of one or more of nine United Nations (UN) hazard classes and, where applicable, to one of three UN packing groups. The nine classes are

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related to the *type of hazard*, while the packing groups are related to the *degree of danger* within the class. The nine hazard classes and three packing groups are outlined below. (See SOP 04-03-XX, "Packaging and Shipping Procedures – Hazardous Materials/Dangerous Goods" for a complete description of each hazard class.)

Every effort should be made to determine the category of the sample (environmental or dangerous goods) prior to collection of samples. Use available file information about the site or areas to be sampled. Review any existing analytical data from previous samples collected at the site. Review waste generation data, where wastes have been disposed on site and any waste characteristic information provided by the facility or other sources (e.g., EPA or State agency).

Sample Category Determination:

When making a determination whether samples can be shipped as Environmental samples, ask the following questions:

Does the sample pose an unreasonable risk to health, safety or property when transported in commerce (e.g., is it shock sensitive, does it emit toxic or noxious gases)?;

Does the sample meet the criteria of one or more of 9 UN hazard classes?
(Attachment A provides definitions for each class):

- Class 1 - Explosive
- Class 2 - Gas
- Class 3 - Flammable liquid
- Class 4 - Flammable solid
- Class 5 - Oxidizer
- Class 6 - Poisonous (toxic)
- Class 7 - Radioactive
- Class 8 - Corrosive
- Class 9 - Miscellaneous dangerous goods

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Is the sample material collected on the list of hazardous material in 49 CFR 172.101 Hazardous Materials Table or the IATA List of Dangerous Goods (IATA Regulations)?; and,

If samples are collected from a drum, tank, impoundment, or other type of source area where hazardous waste/materials are known to be or highly suspected to have been disposed, these samples **DO NOT** qualify as environmental samples. **STOP** and proceed to SOP No. 04-03-XX.

If any of these cases are true, samples must be shipped as a Dangerous Goods. Refer to SOP 04-03-XX for Dangerous Goods Shipping Procedures.

Otherwise, proceed with shipping the environmental samples according to the following procedures.

General Procedures

Environmental samples of solid waste, soil, air or water collected for the sole purpose of testing to determine its characteristics or composition, are excluded from the requirements of 40 CFR 261-270 when: the sample is being transported to a laboratory for purpose of testing; and the shipper complies with DOT, IATA or other applicable shipping requirements.

The appropriate shipping procedures for Environmental samples are detailed in this SOP.

Related SOPs

This SOP is to be used in conjunction with the other relevant or applicable SOPs found in the following SOP categories.

| <u>Category No..</u> | <u>Category Title</u> |
|----------------------|---|
| 01 | General Standard Operating Procedures |
| 02 | General Field Procedures |
| 03 | Field Documentation Procedures |
| 04 | Packaging and Shipping Procedures |
| 05 | Field Equipment Operation and Maintenance Procedures |
| 06 | Groundwater Sampling/Monitoring and Analysis Procedures |

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| | |
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| 07 | Soil/Sediment Sampling and Analysis Procedures |
| 08 | Surface Water Sampling and Analysis Procedures |
| 10 | Regulatory Compliance Procedures |
| 11 | Quality Assurance Procedures |
| 12 | Incineration/BIF Sampling and Analysis Procedures |
| 13 | Waste Sampling and Analysis Procedures |

Related Documentation

The following documents should be used in conjunction with this SOP regarding the packaging and shipment of environmental samples.

- Field Logbook;
- Site Sampling and Analysis Plan;
- Health and Safety Plan; and
- Other relevant facility/site information.

Procedures for Packaging and Shipping Environmental Samples

The procedures for packaging and shipping environmental samples are split into four sections: pre-field preparation of the coolers; preparation of sample containers for shipment; preparation of coolers for shipment; and preparation of the shipping documentation.

Prior to any field activities requiring shipments of samples via FedEx or other transportation service (e.g., UPS), contact the shipping company and determine the following: nearest location of the transporter's drop-off office to the field activities; and operating hours of the nearest office.

Pre-field Cooler Preparation

- (1) Ensure that a sufficient number of coolers have been acquired to allow all samples to be shipped. Use clean, insulated coolers and remove all tape, markings, labels, and custody seals remaining on the outside of the coolers. If possible, the coolers should be washed inside and out prior to use.

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As a guide, the approximate number of bottles fit in a 54-quart cooler:

Organic Water

1 liter ambers: 12
and 40 ml vials: 6
18

or

Inorganic Water

500 ml poly and/or
1 liter poly: 18 to 20

or

Soils

8 oz. glass and 120 ml glass: 30 to 35

Sample Container Preparation

Once samples have been collected, the following steps should be taken in preparing samples for shipment.

- (1) Groundwater, surface water and soil environmental samples may require preservation prior to shipment to the laboratory. Refer to SOPs Series Nos. 06-XX-XX, 07-XX-XX and 08-XX-XX for sample preservation techniques and the project-specific Quality Assurance Project Plan (QAPP) requirements.
- (2) Label all samples according to the procedures outlined in SOP No. 02-04-XX. Either sample container labels or sample tags may be used.
- (3) Wrap each glass bottle with bubble wrap or use bubble wrap bags. Measure out a piece of bubble wrap large enough to surround the entire bottle. The bubble wrap helps protect the sample containers from breakage during transport. Use tape to secure the bubble wrap around the bottle. There is no need to wrap plastic sample containers with bubble wrap.

For VOA sample containers (40 ml vials), spread out a sheet of bubble wrap one or two sheets long. Two to three vials (i.e., one sample) will be wrapped together using the prepared sheet. Place a vial on the top corner, horizontally, on the width end of the bubble wrap. Starting from the vial

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end, roll the bottles into the remaining bubble wrap. When complete, bend the long roll into a V, and tape the package.

- (4) Place each sample container (with the exception of very large containers, e.g., one-gallon amber jugs) inside a resealable zip-lock-type plastic bag (two resealable zip-lock-type bags may be utilized for the one-gallon amber jars). Custody seal tape may be placed around the bag if additional security is desired. For large containers, if a large zip-lock-type bag is not available, wrap the bottle in bubble wrap and place the container in a clean, unused garbage bag. Tape the opening of the bag closed.

Cooler Preparation

- (5) Secure and tape the drain plug on the outside of the cooler with fiber or duct tape to prevent leakage from the plug should a sample container or ice bag leak inside the cooler.
- (6) Place each labeled, wrapped and bagged sample container in the cooler in an upright position. Cardboard separators may also be placed between the sample jars at the discretion of the shipper.
- (7) Fill several large (quart or gallon size) plastic bags (e.g., zip-lock bags) with ice and place each bag of ice within a second zip-lock bag. Place the zip-lock side of the ice filled bag, down into the second bag. (Ice bags are double-bagged to prevent water leakage when the ice melts during transit.) Dry ice should not be used to cool the samples since it is a regulated dangerous good. If dry ice is required for shipment (as in the case of biological tissue sample shipment), the IATA Dangerous Goods Regulations or SOP 04-03-XX should be consulted for the proper packing and shipping instructions.

Place the ice bags around the sample containers inside the large outer plastic (garbage) bag to keep the samples cool during shipment. Fill the remainder of the cooler with bubble wrap or other appropriate packing material. Remember to place a temperature blank into the cooler prior to sealing and shipping (see project specific QAPP for applicability).

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- (8) Complete the Chain-of-Custody form and place it along with the necessary sample documentation forms (i.e., Chain-of-Custody, Contract Laboratory Program Traffic reports etc.) inside a zip-lock plastic bag. The procedures for completing the Chain-of-Custody paperwork are discussed in SOP Nos. 02-05-XX. Tape the plastic bag containing the paperwork to the underside of the cooler lid. Close the cooler lid and tape the cooler latch shut to prevent accidental opening during shipment.
- (9) Wrap each end of the outside of the cooler with strapping tape such that it cannot be opened during shipment. Normally, the tape is wound around the outside of the cooler for a total of three (3) turns, at both ends of the cooler. Up to two custody seals should be affixed to each side of the cooler across the lid opening so that the cooler cannot be opened without breaking the seals. To prevent the accidental tearing of the seal during shipment, it is advisable to place clear packaging tape over the seal. This ensures that the custody seal is firmly affixed to the cooler, yet it can be seen through the thin layer of tape.

Shipping Paperwork Preparation

- (10) If shipping by air, obtain a standard FedEx airbill. If shipping samples for a government client, use a TechLaw Government FedEx account number.
- (11) Attach a label marked as FROM:, containing the name and address of the shipper to the outside of the cooler lid in the upper left hand corner. In the right hand upper or lower corner of outside cooler lid, place another label marked as TO:, containing the name, address and contact person of the recipient of the cooler. These labels are attached to the cooler as added security in case the FedEx label becomes separated from the cooler. See Diagram A for a visual example.
- (12) Complete the shipper's airbill with the appropriate information. Be sure to include a TechLaw job number in the FedEx box labeled for 'Internal Billing Reference Information.' See Attachment B for an example. Fill in the weight of the package, if you have it. If not, FedEx will complete the information related to the weight of the package. Once completed, affix a TechLaw FedEx airbill or plastic airbill pouch to the outside, center

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of the cooler lid. FedEx has airbills that affix to cooler handles and these may be used in place of other airbills. If an airbill pouch is used, slip the completed FedEx airbill into the pouch. Do not seal the pouch. Make sure you pull the top copy of the FedEx airbill before relinquishing the cooler to FedEx. The copy of the airbill should then be placed into the project files.

Health and Safety Section

It is TechLaw's policy to maintain an effective program for control of employee exposure to chemical, radiological, and physical stress which is consistent with the EPA, DOE, and OSHA established standards and requirements.

All field personnel will be provided with appropriate protective clothing and safety equipment. At a minimum, this will include steel-toed shoes, safety glasses, and chemical-resistant gloves.

Refer to a site-specific health and safety plan for detailed health and safety procedures. This plan should be reviewed prior to beginning any work.

QA/QC Section

Prior to sealing coolers, the Field Team Leader should check all paperwork, address labels and shipping documents for accuracy.

Any deviations in preservation techniques should also be documented in the field logbook and justified. Deviations are to be sufficiently documented to allow repetition of the activity as actually performed.

Comments/Notes

Prior to commencing field activities, ensure that appropriate equipment is readied for the activities. In addition, obtain the location, phone number and office hours of the FedEx office nearest to the field activity site.

Attachments

Attachment A: Sample FedEx Airbill

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Attachment B: Diagram of Labeled Cooler.

References

International Air Transport Association (IATA), Dangerous Goods Regulations, Effective from 1/1 to 12/31 of each year.

TechLaw, Corporate Quality Management Plan, most recent version.

TechLaw, Health and Safety Program Plan, most recent version.

U.S. Environmental Protection Agency, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), U.S. EPA Region IV, November 2001.

U.S. Environmental Protection Agency, A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, Washington, D.C., 1987.

U.S. Environmental Protection Agency, Characterization of Hazardous Waste Sites - A Methods Manual, EPA/600/4-84/075, April 1985.

U.S. Environmental Protection Agency, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, OWSER-9950.1, September 1986.

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ATTACHMENT A [Revised 03/01/11]
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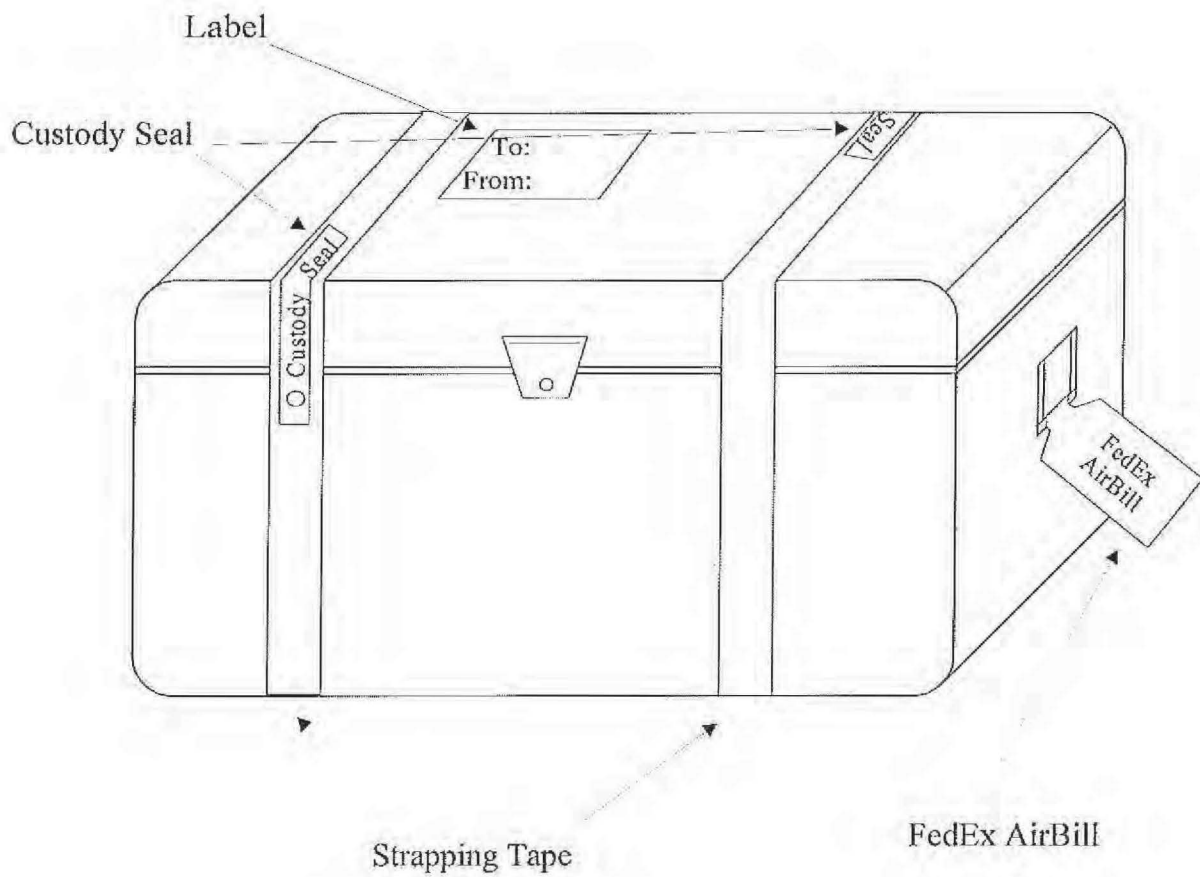
SAMPLE FEDEX AIRBILL

| FedEx US Airbill | | Sender's Copy | |
|---|----------------------------------|--|--|
| Express | | 0200 | |
| 1 From From previous product | | 4a Express Package Service | |
| Date 10-1-07 | Sender's FedEx Account Number | <input checked="" type="checkbox"/> Priority Overnight <input type="checkbox"/> Standard Overnight <input type="checkbox"/> 2 Day <input type="checkbox"/> Next Business Day <input type="checkbox"/> International Priority <input type="checkbox"/> International Economy <input type="checkbox"/> International First Class <input type="checkbox"/> International Bulk Mail | |
| Sender's Name Jane Sampler | Phone 703 818-1000 | <input type="checkbox"/> FedEx 2 Day <input type="checkbox"/> FedEx International Priority <input type="checkbox"/> FedEx International Economy <input type="checkbox"/> FedEx International First Class <input type="checkbox"/> FedEx International Bulk Mail | |
| Company TechLaw, Inc. | | <input type="checkbox"/> FedEx 2 Day <input type="checkbox"/> FedEx International Priority <input type="checkbox"/> FedEx International Economy <input type="checkbox"/> FedEx International First Class <input type="checkbox"/> FedEx International Bulk Mail | |
| Address 14500 Avion Parkway, Suite 300 | | <input type="checkbox"/> FedEx 2 Day <input type="checkbox"/> FedEx International Priority <input type="checkbox"/> FedEx International Economy <input type="checkbox"/> FedEx International First Class <input type="checkbox"/> FedEx International Bulk Mail | |
| City Chantilly | State VA Zip 20151 | <input type="checkbox"/> FedEx 2 Day <input type="checkbox"/> FedEx International Priority <input type="checkbox"/> FedEx International Economy <input type="checkbox"/> FedEx International First Class <input type="checkbox"/> FedEx International Bulk Mail | |
| 2 Your Internal Billing Reference | | 5 Packaging | |
| FedEx account and agree to bill: | | <input type="checkbox"/> FedEx <input type="checkbox"/> Employee* <input type="checkbox"/> Other | |
| 3 To Recipient's Name Allen Lab | | <input type="checkbox"/> FedEx <input type="checkbox"/> Employee* <input type="checkbox"/> Other | |
| Company We Test It Lab | | <input type="checkbox"/> FedEx <input type="checkbox"/> Employee* <input type="checkbox"/> Other | |
| Address 3232 Mockingbird Lane | | <input type="checkbox"/> FedEx <input type="checkbox"/> Employee* <input type="checkbox"/> Other | |
| City Bullsville | | <input type="checkbox"/> FedEx <input type="checkbox"/> Employee* <input type="checkbox"/> Other | |
| State IL Zip 20202 | | <input type="checkbox"/> FedEx <input type="checkbox"/> Employee* <input type="checkbox"/> Other | |
| 6 Special Handling | | <input type="checkbox"/> Fragile <input type="checkbox"/> Perishable <input type="checkbox"/> Hazardous <input type="checkbox"/> Live Animals <input type="checkbox"/> High Value <input type="checkbox"/> Restricted <input type="checkbox"/> Other | |
| 7 Payment Bill to | | <input type="checkbox"/> Recipient <input type="checkbox"/> Third Party <input type="checkbox"/> Credit Card <input type="checkbox"/> Cash | |
| 8 Total Packages | | Total Weight | |
| Total Packages | | Total Weight | |
| Total Packages | | Total Weight | |

TECHLAW STANDARD OPERATING PROCEDURE

ATTACHMENT B [Revised 03/01/11]
SOP Number: 04-02-02

SAMPLE COOLER



**QUALITY ASSURANCE PROJECT PLAN
DIMOCK RESIDENTIAL GROUNDWATER SITE
REVISION 0
February 2012**

APPENDIX C

**COLLECTION OF GROUNDWATER SAMPLES FROM DOMESTIC AND
MUNICIPAL WATER WELLS FOR DISSOLVED GAS ANALYSIS,
ISOTECH LABORATORIES INC.**

Collection of Ground Water Samples from Domestic and Municipal Water Wells for Dissolved Gas Analysis

These instructions are based on sampling protocol created by Anthony Gorody, adopted by the Colorado Oil and Gas Conservation Commission, and are reproduced here with their permission.

The basic technique is to fill a white 5 gallon bucket with source water and then fill the 1 liter sample collection bottle fully immersed in the bucket.

When sampling from a pressurized water system, it is recommended to use an outdoor spigot or other source which bypasses any water treatment systems (i.e. water softeners, etc.).

To collect a sample for isotopic and chromatographic analysis from water that is not effervescent, using 1L bottle with septum cap:

After purging the well, fill the 5 gallon bucket with water. Attach a nozzle and 12" length of ¼ inch diameter tubing to the end of the 5/8 inch hose connected to a faucet. Make sure that the flow rates through the tubing are low. Remove the cap of the 1 L bottle and fill it with water. Once the bottle filled, immerse it in the 5 gallon bucket full of water, keeping the tubing at the bottom of the bottle. Place the bottle at the bottom of the bucket under a head of water, and keep water flowing at a low rate until another 2 volumes of water have been displaced from the bottle. Then slowly lift the tubing out of the bottle and immediately cap it under water. No air should be allowed into the 1 L bottle. When finished, tape the cap to the bottle around the neck, pack the bottle upside down in ice, and ship it overnight.

To collect a headspace gas sample from an effervescent water well:

Fill the bottle with water. Submerge the bottle into the 5 gallon bucket filled with well water and invert it. Insert the ¼ inch tubing into the bottle, increase the flow rate to 2-3 gpm and allow the bubbling gases to displace water in a headspace until 1/4 to 1/2 of the water in the bottle has been displaced. Seal the container under water with the septum and screw cap, tighten it securely. When finished, tape the cap to the bottle around the neck, pack the bottle upside down in ice, and ship it overnight.

Please note Isotech's receiving hours of **Monday thru Friday** 8:00 am to 4:30 pm.

Ship samples to:

Isotech Laboratories, Inc.
1308 Parkland Court
Champaign, IL 61821

These instructions have been provided to simplify the collection of samples for dissolved gas analysis. Although we try to foresee and avoid problems in the field, it is never possible to predict every situation. If you encounter any difficulties, or if any additions or changes in these instructions would be beneficial, please let us know. Isotech Laboratories, Inc. makes no warrantee as to the applicability and/or safety of the procedures described herein.